March 1959
75c.

SEMICONDUCTOR PRODUCTS

SEMICONDUCTOR PRODUCTS

SANFORD R. COWAN, Publisher

March 1959 Vol. 2, No. 3

Front Cover

Depicted are a number of basic semiconductor devices. Shown from left to right are a Power Diode (Bradley), a Piezoresistance Generator (Bell Labs), Transistors (GE), a Thermoelectric Generator (Minnesota Mining), a Magneto-resistance Device (Ohio Semiconductors), an Electroluminescent Device (Sylvania), a Photo Junction Cell (RCA), a Silicon Solar Cell (International Rectifier). These are but a few of the semiconductor devices presently being manufactured or in various stages of development. Subsequent issues of SEMICONDUCTOR PRODUCTS will devote much of its editorial coverage to ever-widening areas of Semiconductor Applications.

SEMICONDUCTOR PRODUCTS is published monthly by Cowan Publishing Corp. Executive and Editorial Offices: 300 West 43rd Street, New York 36, N. Y. Telephone: JUdson 2-4460. Subscription price: $6.00 for 12 issues in the United States, U. S. Possessions, APO, FPO, Canada and Mexico, $8.00 for 12 issues. All others: 12 issues $10.00. Single Copy 75¢. Accepted as controlled circulation publication at Bristol, Conn.

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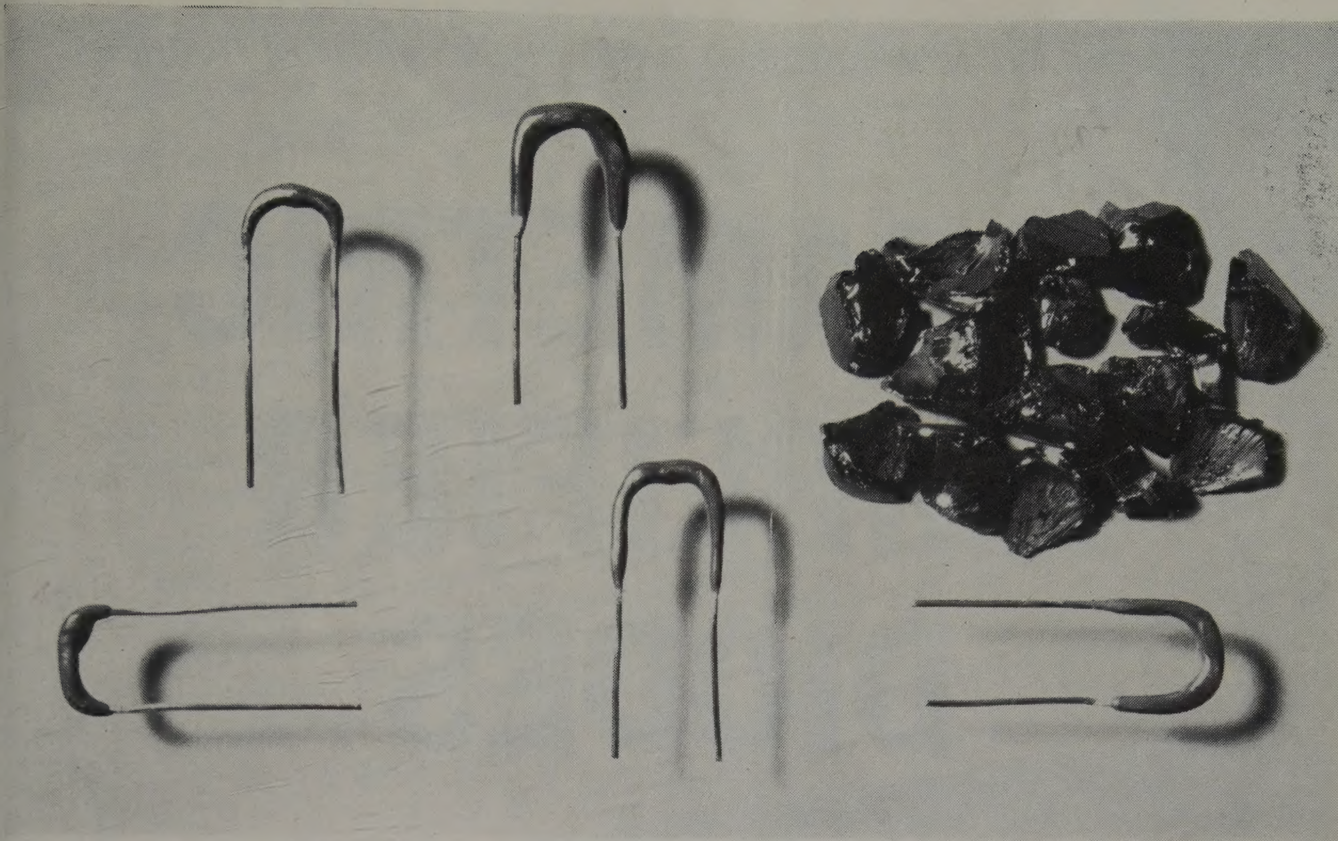

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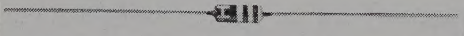
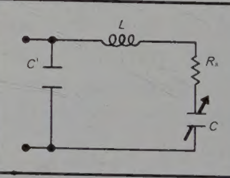
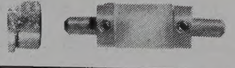
TECHNICAL SPECIFICATIONS AND DATA:

Package (actual size)	C′	C @ zero bias (nominal)	cutoff frequency* (nominal)	L (nominal)	V_S** Min.	V_S** Nom.	Equivalent Circuit
HPA 2800 	0.1$\mu\mu$f	2.5$\mu\mu$f	70KMC	4mμh @ 1KMC	5V	7V	
HPA 2810 	0.2$\mu\mu$f						

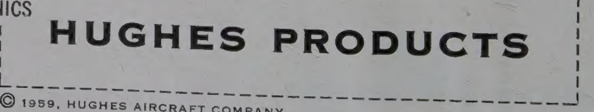
*At breakdown voltage **Breakdown voltage (10μA point)

Address inquiries to:
Hughes Products, Semiconductor Marketing Dept., P. O. Box 278, Newport Beach, California.

CAPACITANCE vs. BIAS VOLTAGE

Reverse Bias Voltage	Capacitance C
0 V	2.5 $\mu\mu$f
3 V	0.76 $\mu\mu$f
7 V	0.60 $\mu\mu$f

Creating a new world with ELECTRONICS



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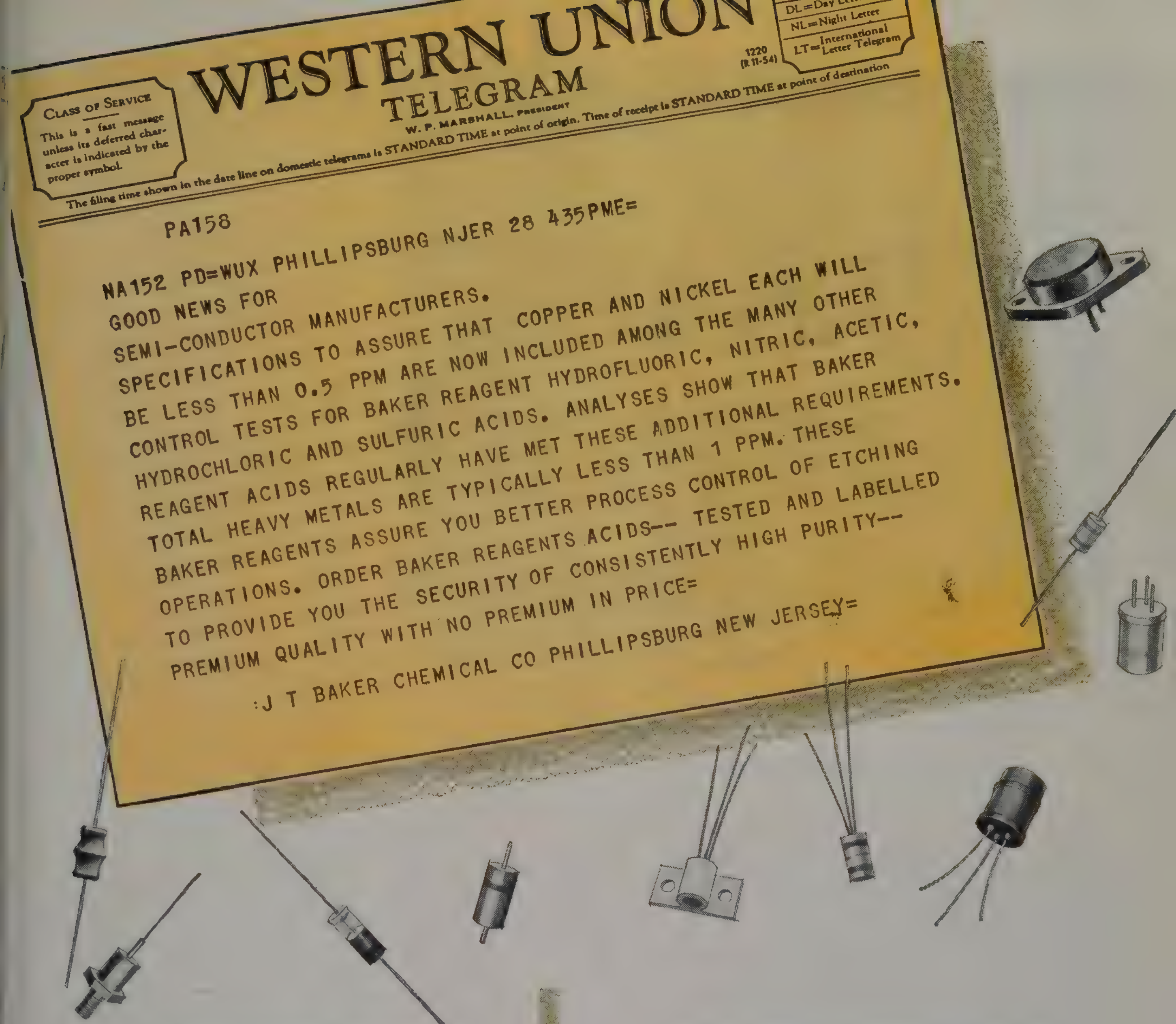

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Acetic Acid, Glacial	Hydrogen Peroxide 30% Solution
Acetone	Methanol
Ammonium Hydroxide	Nitric Acid
Carbon Tetrachloride	iso-Propyl Alcohol
Chloroform	Sodium Carbonate
Ether, Anhydrous	Sodium Hydroxide
Hydrochloric Acid	Sulfuric Acid
Hydrofluoric Acid	Xylene

OTHER ELECTRONIC CHEMICALS

Acetic Acid	Lithium Carbonate
Aluminum Nitrate	Lithium Nitrate
Aluminum Sulfate	Lithium Sulfate
Ammonium Carbonate	Magnesium Carbonate
Ammonium Chloride	Magnesium Chloride
Ammonium Phosphate	Magnesium Oxide
Antimony Trioxide	Manganous Carbonate
Barium Acetate	Methanol
Barium Carbonate	Nickelous Chloride
Barium Fluoride	Nickelous Nitrate
Barium Nitrate	Nickelous Sulfate
Benzene	Nitrate & Oxide
Boric Acid	Nitric Acid
Cadmium Chloride	Potass. Dichromate
Cadmium Nitrate	Potass. Hydroxide
Cadmium Sulfate	Radio Mixtures
Calcium Carbonate	Silicic Acid
Calcium Chloride	Sodium Chloride
Calcium Fluoride	Sod. Phos. Dibasic
Calcium Nitrate	Strontium Nitrate
Calcium Phosphate	Sulfuric Acid
Ether, Petroleum	Toluene
Hydrochloric Acid	Triple Carbonate
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BOOK REVIEWS . . .

TITLE: Electronic - Engineer Reference Book

AUTHOR: L. E. C. Hughes

PUBLISHER: The MacMillan Company, 1958

The Electronic Engineers Reference Book is an unusual collection of the works of many experts in the field, notably British. The book is unusual chiefly in its presentation and scope of coverage.

The reader is introduced to the "Fundamentals" section of the work by means of an interesting history of modern electronics. A general presentation of science as applied to propagation follows, together with a discussion of information theory and noise. Atomic physics, a complete periodic table and a review of radiation lead the reader to an outline of the uses of radiation in the sterilization of foodstuffs and for atomic dating.

Section II of the book continues "Radiations" in terms of actual use. Infra-Red, Ultra-Violet and Photoelectric applications are discussed. Atmospheric pollution, RF Glueing, Electrofax, and induction heating are just a few of the industrial uses of radiation meticulously described.

The third section deals with "Electrics" or components, measurements and electron flow. The industrial applications are again stressed. Radiography, Gamma-Ray therapy, applications of Ferrites and Piezo crystals are but several topcs of many.

Section IV reviews vacuum tubes and transistors. This section is a rather comprehensive review of electronics and deals with a myriad of electronic applications and circuits. The material is well presented in this section which is more tutorial than most of the book. The balance of the work discusses Materials, Vibrations, Computers and Automation.

Electronic Engineers Reference Book is a highly readable survey of electronics as a practical science applied to the industrial applications. Methods, application theory and engineering approach are clearly defined together with a wealth of information. The novel presentation and well written discussions of equipment should highly recommend this work to the library of the electronic design engineer.

TITLE: Electron-Tube Circuits

AUTHOR: Samuel Seely

PUBLISHER: McGraw Hill 1958

This book is the second edition of a work well known in the field of electronics and deals with the practical application of electronic devices.

The first chapter is a rather clear presentation of the characteristics of vacuum tube, transistor and other specialized devices such as the thyratron and ignitron. These devices are discussed in terms of their characteristic curves and physical operation.

The second chapter discusses the vacuum triode and the transistor as analogous topics. The transistor material is illustrated in part by comparison with the equivalent triode vacuum tube.

The major portion of the book is devoted to the many electronic applications of tubes, and although transistors are discussed frequently in the course of presentation, the real value of this book lies in the clarity of presentation of the tube circuits. The chapters on untuned amplifiers, feedback in amplifiers and rectifiers are unusually concise.

Chapter eight is an especially good discussion of electronic computing circuits. This discussion and the equivalent circuit of the difference amplifier is quite thorough as is the author's analysis of the summing and operational amplifier.

The balance of the book presents material on oscillators, tuned and untuned power amplifiers sweep and non-sinusoidal oscillators. There are chapters on amplitude modulation, frequency modulation and detection.

Electron-Tube Circuits presents a clear, physical picture of the actual operation of electronic circuits followed by a thorough mathematical treatment. This book will undoubtedly continue to find its well earned place as a text book and general reference for the electronic design engineer.

TITLE: Fundamentals of Transistors, 2nd Edition

AUTHOR: Leanord Krugman

PUBLISHER: John F. Rider, Publishers

Fundamentals of Transistors is an interesting introduction of the transistor to the engineer. The book is divided into seven chapters which, for the most part, are devoid of tedious mathematics and are quite tutorial.

Basic Semiconductor Physics is discussed in Chapter I, followed by transistors and their operation in Chapter II. These chapters inductively build the transistor out of its physics. Types such as the Surface Barrier, Drift, Avalanche and Spacistor are discussed.

Chapter II is a well written presentation of the transistor in the grounded-base configuration. The network theory is developed together with a series of graphs on transistor circuit characteristics. Operating equations are derived and examples are worked out to illustrate technique and orders of magnitude.

Chapter IV is a similar presentation of the transistor in the grounded-emitter and grounded-collector configurations. Again, the various transistor equations and equivalent networks are defined and the comparison is made of the three basic configurations. Transistor limitations and methods of parameter measurements are outlined.

The balance of the book deals with the transistor as a circuit element. The low frequency amplifier, oscillator and high frequency amplifier are clearly reviewed with the examples of circuitry and methods of bias stabilization described. A complete list of references for advanced study are included at the end of every chapter together with sample problems.

Fundamentals of Transistors (2nd Edition) is a completely revised and updated version of an early work by Krugman. Errors in the first text (PNP transistors were labeled NPN) have been corrected making this book a very useful primer for the advanced technician and uninitiated design engineer. The book is practical in approach and permits a ready understanding of the transistor circuitry described.

Stephen E. Lipsky

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1N253	100	1000	—	—	0.1*	Stud	1024A
1N254	200	400	—	—	0.1*	Stud	989B
1N255	400	400	—	—	0.15*	Stud	990B
1N256	600	200	—	—	0.25*	Stud	991B
1N538	200	—	750	250	0.350†	Axial Lead	1084A
1N540	400	—	750	250	0.350†	Axial Lead	1085A
1N547	600	—	750	250	0.350†	Axial Lead	1083A

*Averaged over 1 cycle for inductive or resistive load with rectifier operating at full rated current; case temperature 135° C.

†Averaged over 1 cycle for inductive or resistive load with rectifier operating at full rated current at 150° C. ambients.

Without qualification, these rectifiers are the finest available today, designed and manufactured to meet stringent government requirements and the exceedingly high quality control standards of General Instrument Corporation.

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(ultra-high-purity)

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The Pechiney process, used in the manufacture of Grace Silicon, is noted for a product with low boron content as well as overall high purity.

May we suggest that whenever top quality silicon is desired—silicon combining both high purity and uniform quality—you get in touch with Grace Electronic Chemicals, Inc., at PLaza 2-7699, 101 N. Charles Street in Baltimore.

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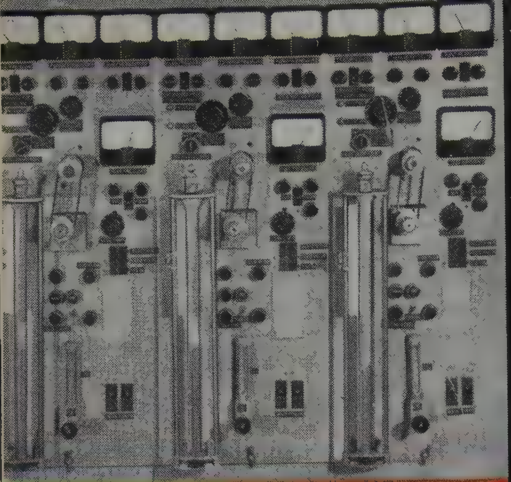

Trancoa's unique automated process assures product uniformity.

TRANCOA SILICON... *Key to increased yields!*

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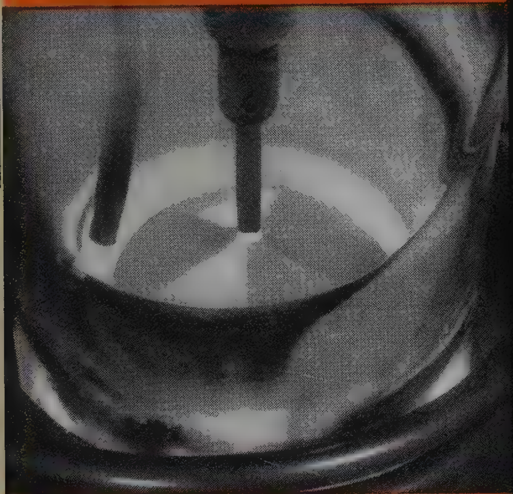

Rigid cleanliness test requires three-sixteenths inch clearance between test crystal and crucible.

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Higher quality silicon can improve your semiconductor device yields. *Trancoa* offers this higher quality at no increase in price!

Grade for grade, the superior quality of Trancoa Silicon is assured by our unique process and exacting specifications. In addition to the standard tests for resistivity, lifetime and base boron level — every lot of Trancoa Silicon must also meet two other important requirements:

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This combination of a new improved process plus added quality standards assures you of receiving better silicon, thus better yields, at no increase in cost.

PRODUCT SPECIFICATIONS

Grade	Resistivity P-Type	Resistivity N-Type	Max. Resistivity Ratio for 10% & 60% Points	Max. Boron Content (ppb)
IA	500	250	3:1	0.5
I	100	50	3:1	0.5
II	50	20	3:1	1.0
III	25	10	3:1	2.0
IV	2.5	1.0	3:1	4.0

For complete information write for brochure, *Trancoa Methods for Evaluating Silicon.*

Trancoa chemical corporation

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on

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is published in

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PRODUCTS

between

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inclusive

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$500.00

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And an engraved

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For further details

See page 42 in this issue.

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BENDIX ANNOUNCES NEW

15-AMP

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Ask for complete details on this new Bendix transistor series . . . and on the complete Bendix line of power rectifiers and power transistors. Write SEMICONDUCTOR PRODUCTS, BENDIX AVIATION CORPORATION, LONG BRANCH, NEW JERSEY.

Current Gain at 10 Adc	Collector-to-Emitter Voltage Rating*			
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20-60	2N1031	2N1031A	2N1031B	2N1031C
50-100	2N1032	2N1032A	2N1032B	2N1032C

*Comparable collector-to-base breakdowns range 20-50% higher.

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Editorial . . .

Luminescence Effect

Luminescence phenomena (fluorescence, phosphorescence) consist of the nonthermal conversion of a source of energy into radiation within the light spectrum. When the source of energy is also a radiation (of frequency higher than that of the light output) the phenomenon is called photo-luminescence. In this case photons of high energy are injected into a crystal (for example zinc sulfide with sodium "activator") and produce hole-electron pairs which wander through the crystal until they recombine at a luminescent center, where light is emitted.

When the source of energy is a beam of highly accelerated injected electrons, the phenomenon is called cathodo-luminescence. In this case the electrons must have sufficient energy to be able to produce hole-electron pairs.

Finally, when the source of energy is a (low frequency) electric field produced within the crystal (in this case the luminescent material is generally suspended in a transparent binder of high dielectric constant), the phenomenon is called electro-luminescence. The hole-electron pairs are produced from donor excitation or avalanche acceleration of valence electrons.

The efficiencies of the three luminescence mechanisms are different: roughly of the order of 200 lumens/watt for photo-luminescence, 100 lumens/watt for cathodo-luminescence and few lumens/watt for electro-luminescence. These efficiencies can be controlled to a certain extent, permitting modulation and amplification. For example, if an *a-c* electric field is produced within a cathodo-luminescent crystal, the efficiency may be decreased in proportion to the frequency of the electric field and in inverse proportion to the density of the injected electron beam. Similarly, the efficiency of electro-luminescence may be increased by superposing a radiation, which increases the density of conduction electrons.

The application of luminescence to the lamp industry, to the television industry, etc., are well known. More recent developments are the light amplifiers, the luminescent displays and the power audio amplifiers. The light amplifier and the luminescent display are based on a sandwich combination of a layer of photoconductive material and one of electro-luminescent material (respectively cadmium sulfide and zinc sulfide, for example). An a-c voltage $V_m \cos \omega t$ is applied in series with the two layers and produces a light output on the electro-luminescent screen proportional to $\sqrt{V_m}$. However, if a light is incident on the photoconductive layer, the conductance of the latter is modulated and this in turn produces a modulation of the field and a corresponding modulation of the output light intensity. Using regenerative feedback, the amplifier is made unstable and acts as a bistable switch, useful for computer application as information storage displays.

Finally the same combination of electro-luminescent and photoconductive layers, without ohmic connection between the two, may be used as a power amplifier. The input signal $V_m \cos \omega t$ is applied to the electro-luminescent material and converted into radiation which in turn is incident on the photoconductive layer and produces modulation of a *d-c* carrier flowing through the load.

Solid State Circuits Conference

The 1959 Solid State Conference held at the University of Pennsylvania on the 12 and 13 of February 1959 was unique in that the presentation of new solid state devices was predominant. It is felt that this is a tremendous assist to the circuit designer who has come out of this conference with a better understanding of the physics and characteristics of new devices he will employ either presently or at some future date.

Of particular interest is the sustained flow of information on nonlinear reactance amplifiers. Several papers were presented on this subject including a survey article and information on wide band amplifiers, the latter showing data which indicated the possibility of obtaining 8-10 db of gain over a 200 megacycle band using çapacitor diodes. The non-linear reactance devices still appear to be the "workhorses" in circuits where they can be applied as opposed to the more sophisticated solid state devices.

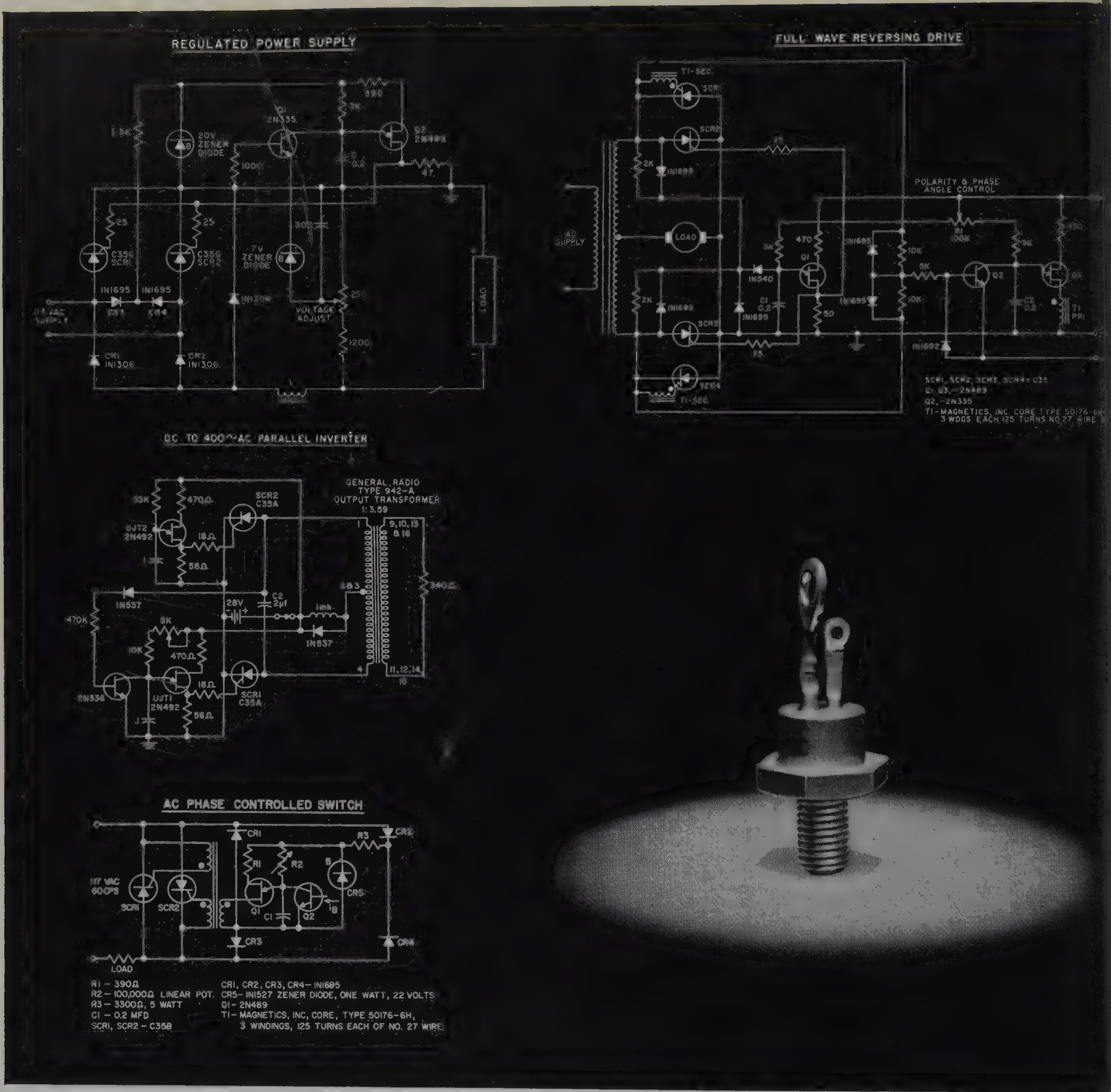
Also presented at the conference was information on other semiconductor devices utilizing the Hall Effect principle, and the superconductor utilized as a switching device. A very excellent tutorial paper was presented on the solid state maser and its applications.

Thus far in the discussion the transistor device has not been mentioned, not intentionally, but because the number of transistor papers presented has decreased. It appears that new applications of the basic transistor structure has been somewhat stabilized, and that it will remain in this state until the device and circuit designer find new modes of transistor operation.

In conclusion it appears that the Solid States Circuits Conference is presenting information not only on device applications but also on new solid state devices as they appear. This, it is felt, is of benefit to the circuit designer. In addition the impression one gets is that the conference is maintaining itself at a level commensurate with the best interests and needs of the research and development circuit designer.

Samuel L. Marshall

New prices, new circuits for



FOUR BASIC CIRCUITS. Above are four basic designs for the Controlled Rectifier using the unijunction transistor as the firing means. The unijunction is a precision trigger, putting out short, high current pulses. The frequency of these pulses will not vary with the supply voltage or temperature, yet can be variably controlled with a silicon triode from a low level feedback signal. Unijunction firing circuits are easily synchronized with 60 cycle line frequency. In short, the unijunction provides the simplest and least expensive means for precision firing of the Silicon Controlled Rectifier.

General Electric's new silicon medium-current rectifiers, Types 1N2154 thru 1N2160, are ideal as companion devices to the controlled rectifier for reverse-voltage protection and, also, for applications in full-wave circuitry.

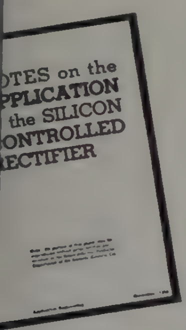
SAMPLE LIST OF POWER HANDLING AND OTHER JOBS THAT CAN NOW BE DONE BETTER BY THE G-E CONTROLLED RECTIFIER

- Converters, DC to DC, DC to AC
- Phase controlled DC power supplies, regulated & unregulated
- Frequency converter, current control
- Power switch for automatic temperature control electronic flash
- Reversible motor control
- AC variable speed induction motor
- Dynamic braking
- Light dimmers
- Thyratron replacement for relay drivers
- Pulse width conversion
- High speed printer for digital computer
- Welding control
- Ignitron firing
- Circuit breaker replace

revolutionary G-E Controlled Rectifier

"Controlled rectifiers may revolutionize the electrical industry." This statement was made a year ago by a respected news publication. Since then samples have been studied by hundreds of firms. Many new circuits have been developed which promise important improvements in functions, reliability, simplicity, accuracy and lower cost. In just one year prices have been reduced 75 percent (see chart below). And now, the G-E Silicon Controlled Rectifier is a standard, production-line item, warranted in writing and available at sharply reduced prices.

This is the time for design engineers to exploit the inherent advantages of the Silicon Controlled Rectifier in their circuit designs. Many applications are proved . . . the firing circuits have been refined . . . the product line is stabilized . . . and it makes sound economic sense. Call or write your G-E Semiconductor Sales Representative for complete details. The Controlled Rectifier is also available from many local G-E Distributors.



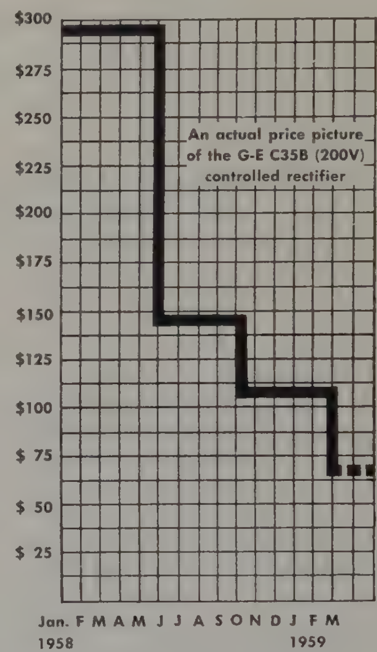
HOW THE G-E CONTROLLED RECTIFIER WORKS. The Silicon Controlled Rectifier is a three junction semiconductor device for use in power control and power switching applications requiring blocking voltages up to 400 volts and load currents up to 16 amperes. Series or parallel circuits may be used for higher power applications.

The G-E Controlled Rectifier's reverse characteristic is similar to a normal silicon rectifier in that it represents essentially an open circuit with negative anode to cathode voltage. The forward characteristic is such that it will block positive anode to cathode voltage below a critical break-over voltage if no signal is applied to the gate terminal. However, by exceeding the forward break-over voltage or applying an appropriate gate signal the device will rapidly switch to a conducting state and present the characteristically low forward voltage drop of a single junction silicon rectifier.

DETAILED NOTES are available on the application of the G-E Silicon Controlled Rectifier, plus reprints of articles that have appeared in technical journals. Write to Section S84359, Semiconductor Products Dept., General Electric Company, Electronics Park, Syracuse, New York.

STEADY PRICE DROP. Since its introduction one year ago, the price of the typical G-E Controlled Rectifier has dropped more than 75 percent. This results from improved manufacturing techniques and volume production. The G-E Controlled Rectifier is now a production-line item, warranted in writing for one year and subjected to the same quality control tests imposed on all General Electric transistors and rectifiers.

The G-E Controlled Rectifier is also available at even less cost (ZJ39L series) for use at 100°C and below, with currents up to 10 amperes.



XIMUM ALLOWABLE RATINGS (Resistive or Inductive Load)

	C35U	C35F	C35A	C35G	C35B	C35H	C35C	C35D
Continuous Peak Inverse Voltage (PIV)	25	50	100	150	200	250	300	400 volts
Transient Peak Inverse Voltage (Non-Recurrent <5 millisec.)	35	75	150	225	300	350	400	500 volts
RMS Voltage (V_{RMS}), Sinusoidal	17.5	35	70	105	140	175	210	280 volts
Average Forward Current (I_F)	Up to 16 amperes							
Peak One Cycle Surge Current (I_{surge})	150 amperes							
Peak Gate Power	5 watts							
Average Gate Power	0.5 watts							
Peak Gate Current (I_G)	2 amperes							
Peak Gate Voltage (V_G) (forward)	10 volts							
Storage Temperature	−65°C to +150°C							
Operating Temperature	−65°C to +125°C							

CHARACTERISTICS (At Maximum Ratings)	C35U	C35F	C35A	C35G	C35B	C35H	C35C	C35D
Minimum Forward Breakover Voltage (V_{BO})	25	50	100	150	200	250	300	400 volts
Maximum Reverse (I_R) or Forward (I_S) Leakage Current (Full Cycle Average)	6.5	6.5	6.5	6.5	6.0	5.5	5.0	4.0 ma
Maximum Forward Voltage ($V_{F\ AVG}$)	0.86 volts (Full Cycle Average)							
Maximum Gate Current To Fire (I_{GF})	25 ma							
Maximum Gate Voltage To Fire (V_{GF})	3 volts							
Typical Gate Current To Fire (I_{GF})	10 ma at +1.5 volts (Gate to Cathode Voltage)							

ZJ39L Series—lower cost series with ratings similar to above, but for use up to 100°C maximum, with forward current ratings up to 10 amperes.
ZJ50 Series—a high-current series now in development, and available on a prototype-sample basis.

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The Application of the Dynistor Diode to "Off-On" Controllers

P. F. PITTMAN*

One important phase of control engineering deals with the design of small "Off-On" controllers which operate from variable resistance-sensing elements. Typical examples of such controls might be photoelectric door openers or thermal overload protectors. When transistor circuitry is used, the size of such controls can be decreased considerably compared with controls using vacuum tubes. However, unless the cost of the control is to be increased, the size of the output relay which can be operated by transistorized controls is quite small. Usually a small sensitive relay must be used at the output of the transistor circuit which in turn controls some larger relay. However, the use of a sensitive relay is objectionable from the standpoints of cost and reliability. Since in many cases the ultimate output of a control is a motor line contactor or other large relay, the most desirable control would have sufficient power to operate this large relay directly. This article describes a semiconductor device for use in small control circuits and which provides high output power.

A NEW SEMICONDUCTOR device has recently been developed at the Materials Engineering Department of the Westinghouse Electric Corporation which can be used in small control circuits to provide high output power with reduced cost and size. This device is a hyperconductive negative resistance diode and has been given the trade name "Dynistor". The V-I characteristic of this diode is shown in *Fig. 1.* The forward characteristic is very much like that of an ordinary germanium diode being characterized by a low voltage and high current. In the reverse direction, the characteristic is again like an ordinary diode until the reverse voltage V_B is reached. The current which flows when the reverse voltage is in the range 0 to V_B is only the diode leakage current. As the reverse voltage approaches V_B, a flattening of the characteristic occurs resulting in a current flow at almost constant voltage. At some current I_B, the diode reaches a negative resistance region and becomes unstable. When the current is increased above I_B, the diode breaks down suddenly to a very low voltage V_H, and as the current is further increased it traverses a hyperconductive region. When the current is reduced to its minimum sustaining value I_S, the diode again becomes unstable and recovers to its breakdown voltage. The Dynistor diode is therefore a highly efficient switch since it displays an essentially nonconducting region as well as a hyperconductive one. Typical laboratory units which have been made at Materials Engineering Department have had breakdown voltages (V_B) ranging from 50V to 230V with breakdown currents (I_B) in the order of 1 to 10 *ma*. The hyperconductive voltage drop is less than 1 volt for currents up to 10 amperes.

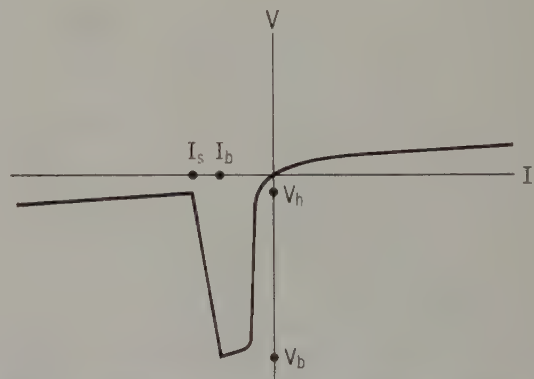

Fig. 1—*V-I* characteristic of the Dynistor diode.

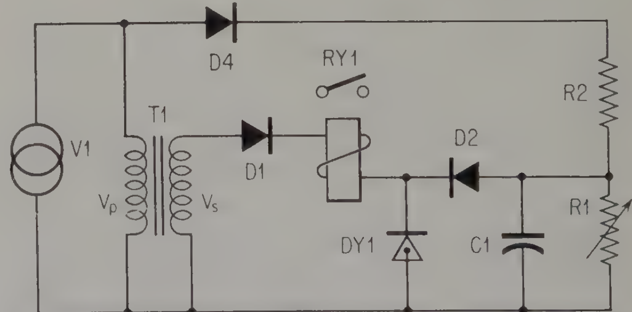

Fig. 2—Control Circuit used to operate a 1 h.p. motor contactor and using a photocell as the sensing element.

The most obvious use of the Dynistor diode would appear to be as a solid-state power switch which could be used to replace relays and provide more reliable switching operations. The Dynistor should find wide use in this application. However, as well as being a useful solid-state switch, the Dynistor diode is a new circuit element which can be used as the

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basis for many new circuits. In this article, three control circuits will be described which use the Dynistor diode in a controlled rectifier application. Part of the third circuit demonstrates the use of the Dynistor diode as a pulse generator.

Control Circuits Using One Dynistor Diode

One of the simplest control circuits is shown in *Fig. 2*. Transformer T_1 is designed so that the peak voltage of V_S is well below the breakdown voltage of Dynistor diode Dy_1. The Dynistor then cannot be made to conduct by the action of V_S alone. The peak voltage of the source (V_1) is well above the breakdown voltage of Dy_1. This voltage is applied across a resistive voltage divider composed of a fixed resistor (R_2) and a variable resistance sensing element (R_1). The value of R_1 determines the peak charge voltage of capacitor C_1 connected across it. The voltage across C_1 is applied through diode D_2 to Dynistor diode Dy_1 causing it to be biased in the reverse direction. If the value of R_1 is such that the peak capacitor voltage is less than the breakdown voltage of Dy_1, no breakdown occurs and no relay current flows. If R_1 is large enough to cause the peak capacitor voltage to reach the breakdown voltage, breakdown occurs allowing relay current to flow. The current which causes the initial breakdown comes from the discharge of capacitor C_1 and soon dies out. In order to keep the Dynistor diode in conduction during the remainder of the positive half cycle, a current greater than its minimum sustaining current must flow through the relay and diode D_1. Since the discharge pulse from C_1 may be as short as 1.0 microsecond, the situation can arise where the inductance of the relay may delay the relay current long enough for the voltage to rise again across the Dynistor diode allowing it to return to its nonconducting state. If this happens, the Dynistor diode will recover immediately from the discharge of C_1 and no relay current will flow. To prevent this condition, it is sometimes necessary to shunt the relay with a resistor just small enough to provide the Dynistor diode minimum sustaining current.

When the Dynistor diode fires, the relay is effectively placed across the transformer for the remainder of the half cycle. The current drawn during this time is then determined by the relay impedance and is limited by the *rms* current rating of the device. At the end of the positive half cycle, the Dynistor diode resets to its nonconducting region in preparation for the next positive half cycle. During the negative half cycle, the flow of current is blocked by diodes D_1 and D_4. In this circuit, as in most Dynistor diode circuits, the output power is independent of the input power since the output power is determined primarily by the load while the input power is determined by the breakdown characteristic of the Dynistor diode.

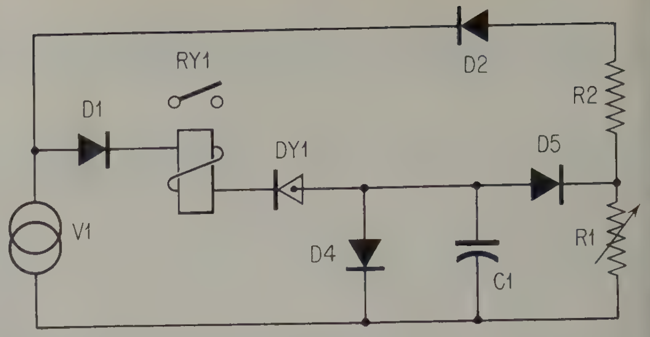

Fig. 3—Control circuit used to operate a 1 h.p. motor contactor and using a thermistor as the sensing element.

In order to obtain a power gain from the circuit, R_1 and R_2 must be high resistances. It is possible to use values of 10,000 ohms or higher and still maintain a reasonable charge time constant since C_1 can be as small as .02 microfarads.

A circuit of this type is better suited for use with a photocell than a thermistor because a reasonably high voltage must be applied to the sensing element. This circuit was constructed using a cadmium sulphide photocell for the sensing element and a 1-*hp* motor contactor for the relay and was found to work very well.

Another simple circuit using only one Dynistor diode is shown in *Fig. 3*. Dynistor diode Dy_1 is chosen so that its breakdown voltage is above the peak voltage of V_1. During negative half cycles, capacitor C_1 charges to some fraction of the peak voltage of the line which is determined by the relative values of R_1 and R_2. Condenser C_1 is prevented from discharging by diode D_5 so that its charge remains when the line voltage goes positive. As the positive half cycle begins, Dynistor diode Dy_1 blocks the flow of current and absorbs both the voltage of V_1 and the remaining charge voltage of C_1 which is in a direction to add to the line voltage. Since now the capacitor voltage adds to the line voltage, the inverse voltage impressed across Dy_1 is greater than the line voltage alone and may be enough to cause breakdown. By making R_1 a variable resistance-sensing element, the peak charge voltage of C_1 may be varied in such a way that when it is added to the peak voltage of V_1 breakdown can either occur or not occur.

If the inverse voltage impressed on Dy_1 is sufficient to cause breakdown, relay current flows through D_1, Ry_1, Dy_1 and D_4 causing the Dynistor diode to remain conducting for the rest of the positive half cycle. As in the other circuits, the relay is effectively placed across the voltage source after breakdown so that the current is determined by the relay impedance.

Since in this circuit the sensing element controls only a fraction of the Dynistor diode breakdown voltage, a lower sensing element voltage can be used compared with the first circuit. A model of this circuit was constructed using a thermistor for a sensing element and a 1-*hp* motor contactor for a relay. The

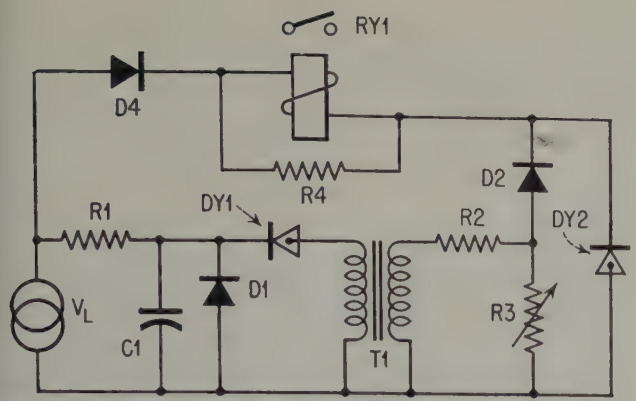

Fig. 4—Circuit design for minimizing variation of calibration with line voltage variations.

model worked very well and showed very little overlap between *"Off"* and *"On"*.

Both of the circuits just described illustrate simple uses of the switching action of the Dynistor diode. In both circuits, the Dynistor diode was used as a switch in a low-voltage, high-current circuit. In the first circuit the Dynistor diode was switched by placing a condenser across it which was charged to its breakdown voltage. In the second circuit, a charged condenser was placed in series with the line to exceed the breakdown voltage. These circuits have both advantages and disadvantages as far as being usable control circuits. Some of the advantages are low cost, small size, high power output, and the elimination of a sensitive relay. They have the disadvantage, however, of changing their calibration with changes in line voltage. In services such as photoelectric counters or door openers, however, where the actual switching light intensity is not important this disadvantage can be overcome.

Control Circuit Using Two Dynistor Diodes

For most applications, circuits must be designed which do not change calibration with line voltage. A circuit in which the variation of calibration caused by line voltage variations has been minimized is shown in *Fig. 4*. This circuit uses two Dynistor diodes and illustrates another method of obtaining Dynistor diode control.

The circuitry to the left of transformer T_1, including Dynistor diode Dy_1, composes a pulse generator which supplies one pulse each cycle of the line. As the voltage V_L of the line rises during the positive half cycle, capacitor C_1 charges through resistor R_1. The charge voltage of the capacitor is also applied across Dynistor diode Dy_1 in the reverse direction causing it to block the flow of current. When the charge voltage of C_1 reaches the breakdown voltage of Dy_1, breakdown occurs causing C_1 to be discharged into the primary of the pulse transformer. The values of R_1 and C_1 can be chosen so that one or more pulses occur during each cycle of the line. Since only a single pulse was necessary for the operation of the other half of the circuit, the values of R_1 and C_1 were chosen for one pulse thereby keeping the dissipation of Dy_1 at a minimum. Very short, high energy pulses are obtained from this circuit because the breakdown time of the Dynistor diode is less than .1 microsecond. Since the breakdown time for the Dynistor diode is so short, very high pulse currents can be obtained using low-impedance pulse transformers.

The function of the left side of the circuit is to supply short, high energy pulses which occur at the voltage maxima of the positive half cycle of the line. These pulses are used to switch the Dynistor diode in the right half of the circuit.

Dynistor diode Dy_2 is used as a controlled rectifier. It is chosen so that its breakdown voltage is well above the peak voltage of V_L. It therefore can never be switched to its hyperconductive region by the action of V_L alone. Since breakdown can occur when the breakdown voltage is exceeded for only .1 microsecond, the pulses supplied by transformer T_1 can easily cause breakdown.

Resistors R_2 and R_3 form a voltage divider network across which the pulse from the transformer is applied. By varying R_3, the peak pulse voltage applied to Dy_2 can be varied above and below its breakdown voltage. Once breakdown occurs due to the pulse from T_1, current flows through D_4, through R_4 and Ry_1 in parallel and through Dy_2. This current is large enough to keep Dy_2 in its hyperconductive region for the rest of the positive half cycle. The voltage across Dy_2 is shown in *Fig. 5*. *Fig. 5a* shows the voltage across Dy_2 when the pulse is below the breakdown voltage. In this case, Dy_2 blocks the flow of current throughout the positive half cycle and all the line voltage appears across it. The trigger pulse can be seen at the maximum point of the positive half cycle. *Fig. 5b* shows the voltage across Dy_2 when breakdown occurs. During the first half of the positive half cycle, Dy_2 blocks. At the maximum point, the trigger pulse occurs causing Dy_2 to break down to a very low voltage. The breakdown is carried over by the relay current causing the voltage across Dy_2 to remain very low for the remainder of the positive half cycle. Since the conducting voltage drop of the Dynistor diode is negligible, the relay is effectively placed across the line after breakdown and the current drawn is determined by the relay impedance. The maximum current is limited by the Dynistor diode dissipation.

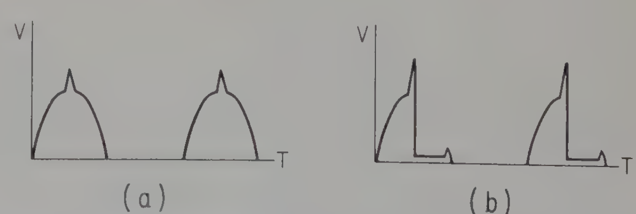

Fig. 5—Voltage across D_{y2} when pulse is below breakdown is shown at (a); (b) shows the voltage wave form when breakdown occurs.

Discussion

The circuits previously described show three different methods of obtaining Dynistor diode control. In the first circuit, breakdown of the Dynistor diode was caused by placing a condenser across it charged to a voltage greater than that necessary for breakdown. In the second circuit, a charged condenser was placed in series with the line to provide sufficient inverse voltage for breakdown. In the third circuit, breakdown was accomplished by applying short, high-energy reverse pulses. Of the three methods, the short pulse method seems to be the most efficient and versatile. It does not require that a high voltage be placed across the sensing element. It results in lower sensing element dissipation, and it is less susceptible to changes in calibration due to line voltage variations. Fortunately, the Dynistor diode also provides an easy way to generate the required pulses.

In all three circuits, the Dynistor diode was used as a switch in a low-voltage, high-current circuit. The three circuits differ only in the way the switch is controlled. Since the Dynistor diode was reset at the end of each positive half cycle by the current zero, the circuits were capable of responding to a change in sensing element resistance within the time of one cycle of the line. The response of the relay was much slower than one cycle however, so the over-all circuit response was approximately that of the relay. Because the Dynistor diode is either *"Off"* or *"On"*, the overlap between the switching resistances is very small compared to ordinary bistable circuits.

In many transistor circuits, the transistor is used as an *"Off-On"* device which quickly traverses its high dissipation region. In this service more power can be controlled by the transistor since its average dissipation is low. The Dynistor diode acts in a similar fashion but has several advantages over the transistor. It can switch much faster than a transistor and therefore has a lower dissipation. Unlike the transistor, the Dynistor diode does not require the continuous flow of input power as long as output power is desired. For this reason, the Dynistor diode is a more efficient switch than the transistor. Another advantage of the Dynistor diode is that it can withstand much higher voltages than presently available transistors. The Dynistor diode provides a new and very useful circuit element which can be used to improve existing circuits and to form the basis for many new circuits.

Transistor AC and DC Amplifiers With High Input Impedance

DR. R. D. MIDDLEBROOK* and C. A. MEAD*

A class of transistor amplifiers is described in which high input impedance is achieved with bias stability comparable with that of ordinary low input impedance amplifiers. Input impedances of several megohms shunted by one or two micromicrofarads are easily realized with simple circuits, and input resistances up to 100 megohms may be obtained with more elaborate circuitry. Other important properties are that input shunt capacitance can be almost completely eliminated, the voltage gain is stabilized, and the output impedance is low. Criteria for best noise performance are discussed. Typical practical measurements are given, and various illustrative circuits are shown for both *a-c* and *d-c* amplifiers.

Introduction

THE INHERENTLY LOW input impedance of a transistor requires specific efforts on the part of the circuit designer to achieve high input impedances in transistor amplifiers. Some form of negative feedback will solve this problem; however, a high degree of bias stability is usually required, and when faced with a practical design one's first conclusion is that high input impedance and high bias stability are incompatible.

Since the emitter-follower configuration offers the highest input impedance of the three, attempts have been made to achieve high input impedances by using one or more emitter followers in cascade, as shown in *Fig. 1*. The input impedance of such a single emitter-follower stage is approximately βR shunted by the parallel combination of the collector resistance and capacitance. By operating the stage at low current, the input impedance may be made high. There are

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three major disadvantages of this arrangement: (1) the operating point is completely unstabilized, since the floating base forces the collector current to be approximately βI_{c0}, where I_{c0} is the collector saturation current, and hence is exponentially dependent on temperature; (2) the input resistance is shunted by the collector capacitance; (3) when driven from a high impedance source, which would often be the case when a high-impedance input is called for, the frequency response is limited by the β cutoff frequency of the transistor. Bachmann has described such an amplifier, containing two emitter followers in cascade[1], with which he is able to obtain input resistances exceeding 50 megohms. Improvements may be made in this basic emitter-follower arrangement by bootstrapping the collector of the first transistor, which decreases the shunting effect of the collector impedance across the input. Such arrangements have been proposed by Stampfl and Hanel.[2]

However, none of the circuits mentioned above contains any form of bias stabilization, and the signal source must be directly connected to the base of the first transistor. Attempts to improve the bias stability must involve setting the voltage level of the input base, which in turn requires a low-impedance bias source such as shown in *Fig. 2*. Thus immediately the previously high input impedance is shunted by the low impedance bias source. However, the input resistance can for the most part be restored by bootstrapping not only the collector of the first transistor, but also its associated bias network. Circuits of this type have been described by Anzalone[3] and Montgomery[4], who have obtained input resistances up to 100 megohms. The bias stability however is not good in either circuit.

All these well-established techniques are applicable to the circuits to be described in this paper, which utilize in addition both negative and positive feedback with greater-than-unity loop gain. Bias stability comparable with that of ordinary low input impedance circuits is obtained. These circuits exhibit, even without bootstrapping, input resistances of the order of megohms with a high degree of bias and gain stability, and moreover the detrimental effects of input-stage collector capacitance and input stray capacitance can be almost completely eliminated. A typical figure for the input impedance of such an amplifier is 4 megohms shunted by 1 *mmf*, measured at the input end of a shielded cable with 73 *mmf* shunt capacitance. If bootstrapping is employed, the input resistance may be increased up to 100 megohms. Examples of both *a-c* and *d-c* high impedance amplifiers will be given.

The noise performance of high input impedance amplifiers is of some importance. Bachmann has discussed the noise figure of two cascaded emitter followers[5], and shown that a minimum noise figure may be obtained with optimum source resistances approaching 1 megohm. However, the addition of a shunt bias network at the input modifies these results to a drastic extent. The noise performance under these conditions is treated in some detail in this paper, and it is shown that there is an upper limit to the optimum source resistance determined by the bias network. It is further shown that different criteria for the best noise performance are applicable if the source resistance is unavoidably higher than the optimum value.

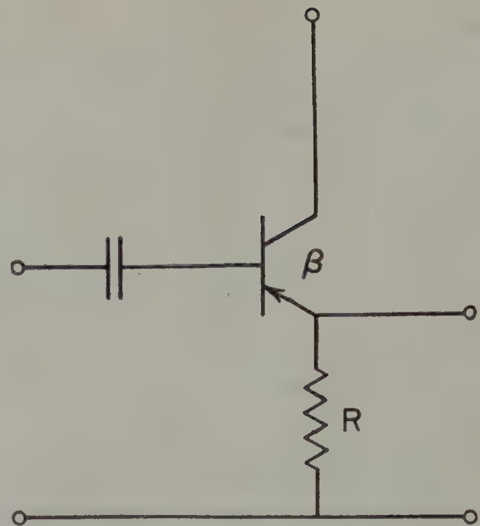

Fig. 1. Basic emitter-follower circuit for obtaining high input impedance

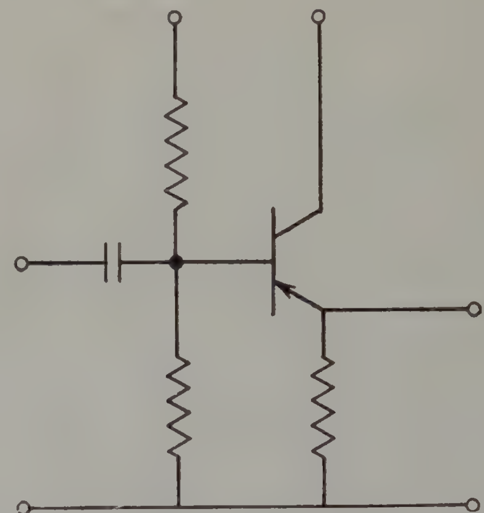
Fig. 2. Bias-stabilized emitter-follower circuit.

Principles of the new high-impedance circuit

The basic form of the new high input impedance *a-c* amplifier is shown in *Fig. 3*. The circuit contains a two-stage common-emitter amplifier, and bias stability is achieved by the battery-resistor combination E_b, R_b, which represents any of the many forms of bias arrangement, such as the potential divider type shown in *Fig. 2*.

Consider first the d-c bias conditions. If R_b is small, the base current of transistor No. 1 is able to take the value required to make the voltage drop across R_1 equal to E_b. Because of the current gain of transistor No. 2, the current through R_2 is almost the same as that through R_1. Thus the voltage across $(R_1 + R_2)$, which is the output d-c level, is approximately $E_b(R_1 + R_2)/R_1$, and is hence stabilized against changes in both the β and the I_{c0} of both transistors. This is a well-known solution to the bias stability problem, but has heretofore been inapplicable to high input impedance circuits because the bias resistor R_b limits the input impedance. However, in the new circuit this difficulty is overcome by the positive feedback link through R_n and C_n, as shown below.

Consider next the a-c signal conditions. A simple a-c equivalent circuit of *Fig. 3* may be drawn as shown in *Fig. 4*. Each transistor is represented by a simple equivalent circuit in which the base and emitter resistances are neglected and the collector current is β times the base current. The collector impedance of No. 2 is neglected since it is in parallel with the relatively small $(R_1 + R_2)$; however, the collector impedance of No. 1 (collector resistance r_c in parallel with the space-charge capacitance C_c) is important, and effectively appears between the input terminal "A" and ground (since the collector of No. 1 is effectively at a-c ground through the base-emitter junction of No. 2). Also appearing between "A" and ground are the bias source resistance R_b and any stray capacitance C_s between the input leads. The four parallel elements r_c, C_c, R_b, C_s may all be lumped together in an admittance Y_i, and the parallel combination of R_n and C_n may be represented by an admittance Y_n.

The following approximations may be made, where the symbols are as defined in *Fig. 4:*

(a) $\beta_2 \gg 1$, hence the current through R_1 is essentially the same as that through R_2.

(b) $1/Y_n \gg R_1 + R_2$, hence $i_f \ll \beta_1\beta_2 i_{b1}$ and the current through R_2 (and R_1) is essentially equal to $\beta_1\beta_2 i_{b1}$.

To compute the voltage gain, consider a signal voltage $+v_1$ applied at the input. Since the base and emitter resistances of No. 1 are neglected, the voltage across R_1 is v_1. Hence, because of approximation (a), the output voltage at "B" is equal to $v_1(R_1 + R_2)/R_1$. Thus the voltage gain G is

$$G = \frac{v_2}{v_1} = \frac{R_1 + R_2}{R_1} \tag{1}$$

and is greater than 1. More detailed analysis shows that the voltage gain is closely given by

$$G = \frac{R_1 + R_2}{R_1}\left(1 + \frac{1}{\beta_2}\frac{R_2}{R_1 + R_2}\right)^{-1} \tag{2}$$

which approaches expression (1) when

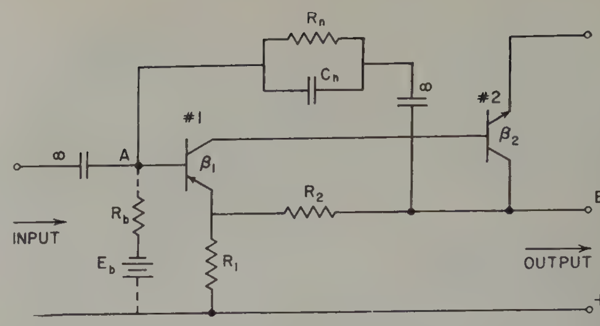

Fig. 3. Basic circuit of a high input impedance, bias- and gain-stabilized amplifier.

$$F = 1 + \beta_2 \frac{R_1 + R_2}{R_2} \gg 1 \tag{3}$$

The parameter F may be called the "feedback factor" and expressed in db.

The input impedance is by definition v_1/i_1, or the input admittance Y_{in} is

$$Y_{in} = \frac{i_1}{v_1} \tag{4}$$

By summing currents at junction "A":

$$i_1 = i_{b1} + i_s - i_f \tag{5}$$

where

$$i_{b1} = \frac{v_1}{\beta_1\beta_2 R_1} \tag{6}$$

$$i_s = Y_i v_1 \tag{7}$$

$$i_f = Y_n(v_2 - v_1) = Y_n\left(\frac{R_1 + R_2}{R_1} - 1\right)v_1 \tag{8}$$

$$= Y_n \frac{R_2}{R_1} v_1 \tag{9}$$

Hence

$$Y_{in} = \frac{1}{\beta_1\beta_2 R_1} + Y_i - \frac{R_2}{R_1} Y_n \tag{10}$$

The interpretation of this result is as follows:

(a) The term $1/\beta_1\beta_2 R_1$ is the admittance at the input of the first transistor, and can easily be made several megohms.

(b) The term Y_i expresses the shunting effect of transistor collector admittance, bias supply resistance, and stray admittance across the input. The bias supply resistance R_b is essential if any attempt is made to stabilize the d-c operating conditions. By proper bootstrapping techniques both R_b and the collector impedance may be raised in effective a-c value, but not

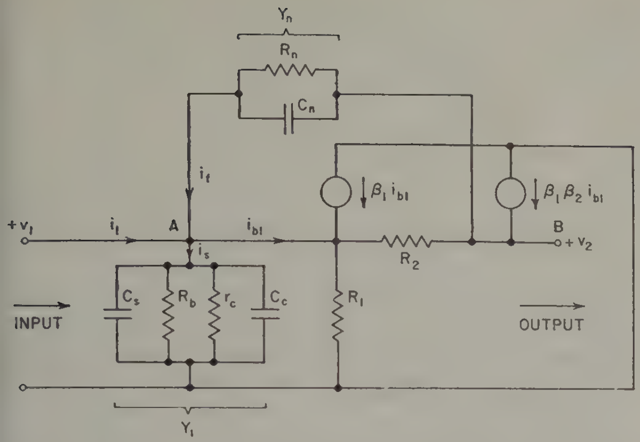

Fig. 4. *A-C* equivalent circuit of the high impedance amplifier of Fig. 3.

eliminated. However, this approach cannot reduce the effect of the stray capacitance C_s, and in general will increase its value with detrimental results.

(c) The term $Y_n(R_2/R_1)$ is a result of the feedback network Y_n and acts to reduce the effect of the other two. Clearly, by proper choice of component values, the input admittance can be made small, zero or even negative.

It might seem that the optimum choice of Y_n would be that leading to zero admittance, or infinite impedance. However, in practice this is undesirable since the adjustment is quite sensitive to changes in $\beta_1\beta_2$. To overcome this problem it is only necessary to choose Y_n such that the second and third terms exactly cancel. This adjustment is independent of transistor parameters. For this condition

$$Y_n = \frac{R_1}{R_2} Y_i \tag{11}$$

The input impedance Z_{in} is then

$$Z_{in} = 1/Y_{in} = \beta_1\beta_2 R_1 \tag{12}$$

which is the theoretical limit obtainable with conventional circuits assuming perfect bootstrapping and no stray input admittance.

Circuit Properties

Under the condition $Y_n = Y_i(R_1/R_2)$ described above, the circuit exhibits the following properties:

(1) Stabilized *d-c* operating conditions determined by the bias supply E_b, R_b and essentially independent of transistor parameters. Various bias methods equivalent to and superior to the bias supply E_b, R_b are discussed later.

(2) Stabilized voltage gain $G = v_2/v_1 = (R_1 + R_2)/R_1$, also essentially independent of transistor parameters.

(3) The input impedance is large, i.e., $Z_{in} = \beta_1\beta_2 R_1$ and remains large up to the β cutoff frequency of transistor No. 1 or No. 2. Note in particular that the stray admittance across the input terminals and the collector admittance of No. 1 do not shunt Z_{in}. These effects have been removed in the circuit adjustment.

(4) The output impedance is low, being (R_2/β_2) if the circuit is driven from a low impedance source.

Circuit Adjustment

Practical adjustment of the circuit to a desired input impedance is conducted as follows. The approximate value of R_n is given by

$$R_n = \frac{R_2}{R_1} R_b \tag{13}$$

which is Eq. (11) for low frequencies and in which the shunting effect of r_c is neglected. The exact value of R_n is set by a dynamic measurement: observe the output voltage v_2 when the input is fed through a source resistance R_g from an oscillator set to some midband frequency, say 1 *kc*. Let the output voltage be v_2 when R_g is present, and v_2' when R_g is short-circuited. The input resistance is then

$$R_{in} = \frac{R_g}{(v_2'/v_2) - 1} \tag{14}$$

and R_n can be adjusted until R_{in} reaches the desired value. For example, if the output voltage is 1 *v* with R_g absent, then the input resistance will be 1 megohm if R_n is adjusted so that the output voltage falls to 0.5 *v* when $R_g = 1$ megohm is inserted in series with the input.

The value of C_n is next adjusted so that the output voltage stays at the same value up to as high a frequency as possible, measured with R_g present and the oscillator output maintained at constant amplitude. It will be found that it is possible in this way to increase the output voltage at higher frequencies above the low-frequency value; this corresponds to over-compensation of the total shunt input capacitance $(C_c + C_s)$. Such a condition is liable to introduce instability, and C_n should be adjusted so that an acceptable degree of peaking, perhaps 10%, is achieved.

Measurements made on a typical circuit after adjustments were made in this way are given later.

Practical A-C High-impedance Amplifiers

Many practical embodiments of the basic circuit of *Fig. 3* are possible. Some general principles will be discussed here.

It has been shown above that high input impedance and good bias stability may be achieved simultaneously by appropriate use of positive feedback. For this method to be successful, it is necessary that the positive feedback path be connected across points between which there is a highly stable voltage gain greater than unity. The input and output terminals "A" and "B" of *Fig. 3* are two such points, the gain stability being greatest when the feedback factor F (Eq. 3) is largest. Bias stability is greatest when R_b

is smallest (other factors being constant) and in principle any required input resistance can be attained by making R_n smaller as R_b is reduced (until R_n becomes comparable with R_2). However, the adjustment will be less critical, and the circuit more stable, if R_b and thus R_n are as large as possible. In the simple circuit of *Fig. 3,* one can do no better than compromise between these two opposing requirements. The same remarks apply, of course, when the separate bias battery E_b is eliminated in favor of the potential divider arrangement shown in *Fig. 5(a).* The effective value of R_b is the merely the value of the parallel combination of the two bias resistors.

By more elaborate circuitry, the above compromise may be alleviated by making the effective *d-c* value of R_b less than the effective *a-c* value, thus allowing the two opposing requirements to be more closely met simultaneously. Several such modifications are shown in *Fig. 5,* in which circuits (*b*), (*c*) and (*d*) may be compared with the basic form (*a*). The positive feedback link R_n and C_n is omitted in all cases for simplicity. Circuits (*b*), (*c*), and (*d*) all contain *d-c* negative feedback from a bypassed resistor R_7 in series with the emitter of transistor No. 2. Circuits (*c*) and (*d*) contain in addition two forms of *a-c* bootstrapping, which may be considered either as negative or as positive feedback.[6] For comparison, the approximate effective *d-c* and *a-c* values of the bias resistor R_b are listed below.

Fig. 5(a):

$$R_b|_{dc} = \frac{R_3R_4}{R_3 + R_4} = R_b|_{ac} \tag{15}$$

Fig. 5(b):

$$R_b|_{dc} = \frac{R_3R_4}{R_3 + R_4}\left[1 + \frac{R_3R_7}{(R_3 + R_4)\,R_1}\right]^{-1} \tag{16}$$

$$R_b|_{ac} = \frac{R_3R_4}{R_3 + R_4} \tag{17}$$

Fig. 5(c):

$$R_b|_{dc} = \frac{R_3R_4}{R_3+R_4}\left[1+\frac{R_3R_4}{(R_3+R_4)\,(R_1+R_{11})}\left(\frac{R_7}{R_4}-\frac{R_1}{R_3}\right)\right]^{-1} \tag{18}$$

$$R_b|_{ac} = \frac{R_3R_{12}}{R_3 + R_{12}}\,\frac{1}{1 - G'} \tag{19}$$

Fig. 5(d):

$$R_b|_{dc} = \left(R_{13} + \frac{R_3R_4}{R_3 + R_4}\right)\left[1 + \frac{R_3R_7}{(R_3 + R_4)\,R_1}\right]^{-1} \tag{20}$$

$$R_b|_{ac} = \frac{R_{13}}{1 - G'} \tag{21}$$

where G' is the voltage gain between the base and emitter of transistor No. 1, and is closely given by

$$1 - G' = \frac{r}{\beta_2R_1} \tag{22}$$

where r is the common-base input resistance of transistor No. 1. If internal feedback in transistor No. 1 is neglected, and if the emitter *d-c* current I_e is fairly small, the internal base resistance may be neglected and r is approximately equal to the Shockley emitter-diode resistance[7] kT/qI_e, where $kT/q = 26\,mv$ at room temperature. It will be observed that $(1-G')$ is extremely small, typically in the order of 0.002, and hence $R_b|_{ac}$ in circuits 5 (c) and (d) may be very large while $R_b|_{dc}$ is quite small. Thus good *d-c* stability may be assured while high *a-c* input resistances may be attained with a minimum of positive feedback through R_n.

Noise performance

It is well-known that an isolated transistor exhibits a minimum noise figure F_m (typically a few *db*) when the source resistance has an optimum value R_{gm} (typically a few thousand ohms). Since an amplifier in which high input impedance is specified is frequently to be used with a high impedance signal source, it is of importance to inquire into the noise properties of such a circuit since the source impedance is so far from optimum.

It has been shown that the minimum noise figure and the optimum source resistance of a transistor at a given operating point are essentially independent of any feedback applied over it, and are affected only by the values of certain circuit components closely associated with the transistor.[8] Moreover, the presence of these circuit components can only increase the minimum noise figure. It therefore follows that in the high impedance circuits presently under consideration the presence of feedback *per se* does nothing to increase the optimum source resistance. The optimum source resistance for the high input impedance circuit is therefore little different from that of the first-stage transistor alone.

The only way in which the optimum source resistance can be significantly increased is to operate the first-stage transistor at low bias currents.[9,10] This is automatically effected in the circuits so far described, since the collector current of transistor No. 1 is identical with the base current of No. 2. Operation under such conditions will usually also result in a lower minimum noise figure. However, the optimum source resistance can not be increased indefinitely by such means because of a circuit limitation. To show this, some results from reference 8 will be quoted. In Eqs. (4) and (5) of reference 8, the optimum source resistance R'_{gm} and the minimum noise figure F'_m of an arbitrary transistor circuit may be expressed in terms of the corresponding quantities R_{gm} and F_m of the

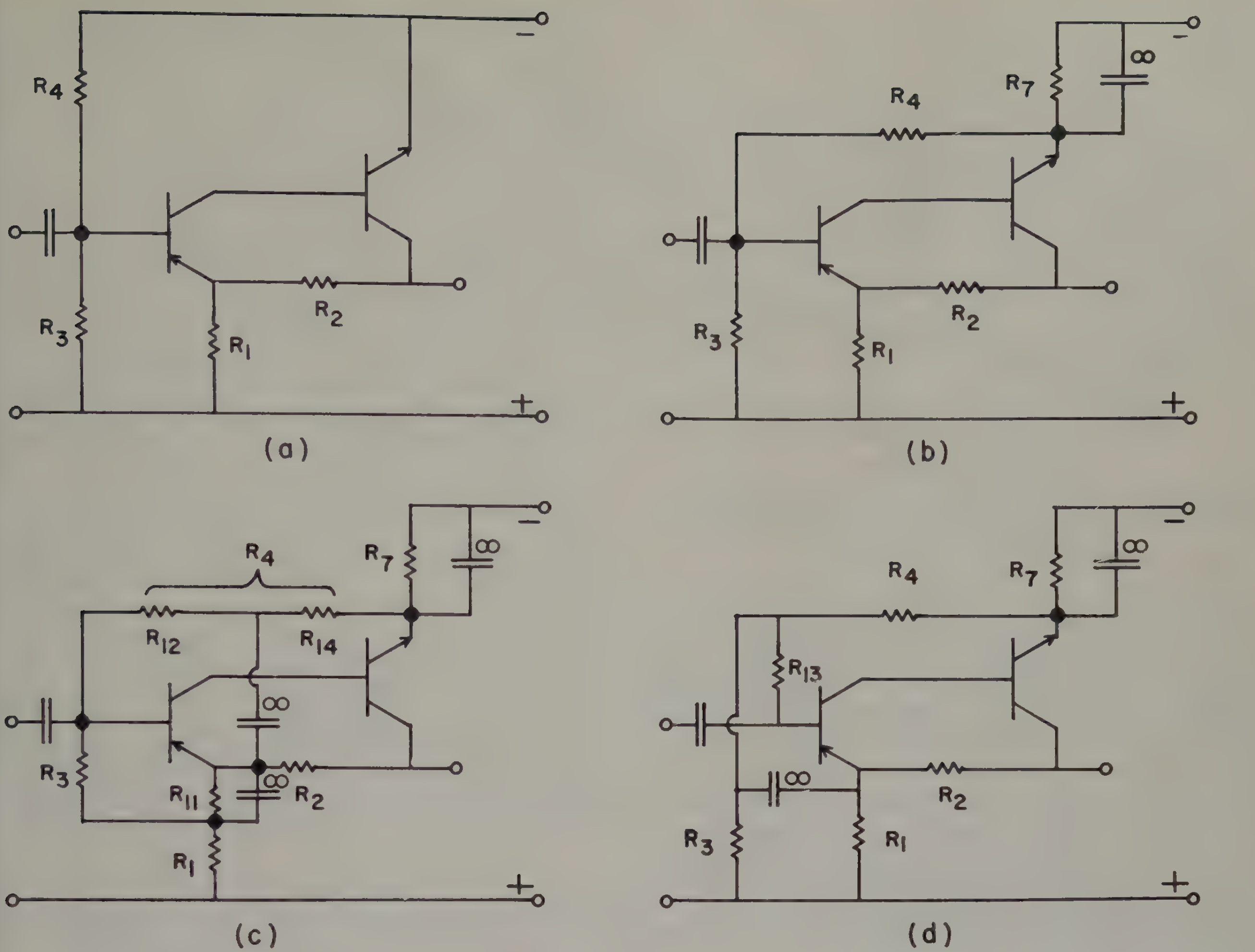

Fig. 5. Four types of bias stabilization and bootstrap circuits.

isolated transistor by the relations

$$\frac{R'_{gm}}{R_{gm}} = \left[\frac{1 + (R_{n2}/R_{gm})^2}{(1 + R_{n2}/R_{n1})^2 + (R_{gm}/R_{n1})^2}\right]^{\frac{1}{2}} \tag{23}$$

$$\frac{F'_m - 1}{F_m - 1} = \frac{R_{n2}}{R_{gm}} + R_{gm}\left(1 + \frac{R_{n2}{}^2}{R_{gm}{}^2}\right)\left(\frac{1}{R_{n1}} + \frac{1}{R_{gm}{}'}\right) \tag{24}$$

where thermal noise generated in circuit resistances (other than the source) is neglected, and where R_{n1} and R_{n2} are effective (noise-wise) resistances from ground to the first-stage transistor input terminal and common terminal, respectively. (The resistances R_{n1} and R_{n2} were represented by R_1 and R_2 in reference 8, but the extra subscript is used here to avoid confusion with other quantities used in the present paper.) For the high input impedance circuits so far discussed, the resistances R_{n1} and R_{n2} are

Fig. 5(a) and *(b)*:

$$\frac{1}{R_{n1}} = \frac{1}{R_3} + \frac{1}{R_6} \qquad \frac{1}{R_{n2}} = \frac{1}{R_1} + \frac{1}{R_2} \tag{25}$$

Fig. 5(c):

$$\frac{1}{R_{n1}} \approx \frac{1}{R_3} + \frac{1}{R_{12}} \qquad \frac{1}{R_{n2}} \approx \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_{14}} \tag{26}$$

Fig. 5(d):

$$\frac{1}{R_{n1}} \approx \frac{1}{R_{13}} \qquad \frac{1}{R_{n2}} \approx \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \tag{27}$$

Note that for noise calculations no effective multiplication of resistances occurs as a result of bootstrapping.

Now let the operating current of transistor No. 1 be reduced so that R_{gm} becomes much greater than either R_{n1} or R_{n2}. It is seen from Eq. (23) that R'_{gm} does not increase indefinitely with R_{gm}, but reaches a limiting value $R'_{gm} = R_{n1}$. As seen from Eqs. (25) to (27), the value of R_{n1} will usually be much less than R_g for high impedance sources and thus matching for minimum noise signal is not possible.

In such circumstances, it is more meaningful to inquire what is the smallest noise figure which can be obtained with a given source resistance R_g and given

R_{n1}, if R_{gm} is considered a variable (through control of the transistor operating current). Although changing the operating current will alter F_m as well as R_{gm}, F_m may be considered constant for the purposes of estimating the smallest noise figure under the above conditions. It is intuitively obvious (since noise generated in R_{n1} has been neglected), or can be shown from Eqs. (6), (7), and (13) of reference 8, that the optimum (smallest) value F'_{opt} of the circuit noise figure which can be obtained with given R_g, R_{n1}, and F_m is obtained when R_{gm} is equal to the parallel combination of R_g and R_{n1}, or

$$R_{gm \cdot opt} = R_g R_{n1}/(R_g + R_{n1}) \tag{28}$$

$$\approx R_{n1} \text{ if } R_g \gg R_{n1} \tag{29}$$

If R_{gm} has this optimum value, F'_{opt} is given by

$$F'_{opt} = F_m + \frac{R_g}{R_{n1}} (F_m - 1) \tag{30}$$

Some methods of controlling the operating current of the first-stage transistor in the basic high input impedance circuits, in order to adjust R_{gm} to its optimum value, are discussed in the next section.

Experimental results

The discussion of noise performance given in the previous section has pointed out the existence of an additional criterion which should be considered in the design of high input impedance circuits, namely, proper choice of the *d-c* operating current of the first-stage transistor. For best noise performance, it may be desirable to operate this transistor at as low a current as possible. This is achieved in the basic circuit of *Fig. 3,* where the collector current of transistor No. 1 is equal to $1/\beta_2$ times the collector current of No. 2, which in turn can be made arbitrarily small by suitable choice of the bias network and supply voltage.

However, as is so often the case, an independent criterion requires a choice of an adjustable parameter which conflicts with the choice of the same parameter required to satisfy another criterion. As discussed already, the highest input impedances are obtained when some form of bootstrapping over the first stage transistor is employed. The bootstrapping is most effective when the quantity $(1 - G') = r/\beta_2 R_1$ is smallest, where r is approximately equal to kT/qI_e (see Eq. 22). Thus if the *d-c* operating current I_e of transistor No. 1 is made small for best noise performance, the bootstrapping will be less effective because the resistance r is increased.

If the highest possible input impedance is more important than low noise figure, it may be desirable to operate the first stage transistor at a higher current level than is permitted by the circuit of *Fig. 3.* This may be accomplished by the circuit of *Fig. 6,* in which the collector current of No. 1 is determined by the *d-c* voltage across R_3 and the emitter bias resistor R_6; the base voltage of No. 2 is determined by the drop across R_8; and the collector current of No. 2 is then fixed by R_7. Bootstrapping of the type shown in *Fig. 5(c)* is employed, and the *a-c* equivalent circuit of this arrangement is identical with that of the basic circuit shown in *Fig. 4,* except that the effective *a-c* value of R_b is increased because of the bootstrapping. It will also be noticed that in *Fig. 6* the blocking capacitor in series with R_n and C_n has been omitted: this improves the low-frequency performance of the amplifier, but has the disadvantage that positive feedback exists at *d-c* which tends to degrade the bias stability.

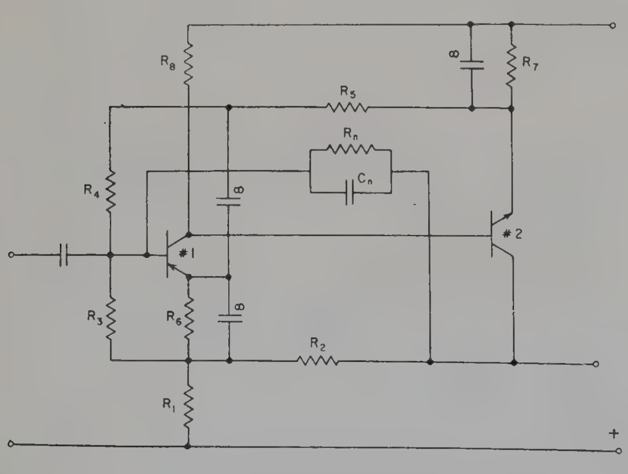

Fig. 6. Possible modifications of the basic high impedance amplifier, including *d-c* negative feedback to increase bias stability, and bootstrapping to increase the input impedance.

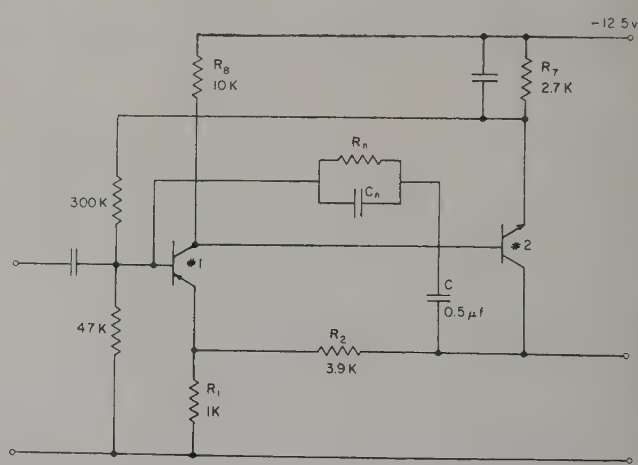

Fig. 7. Practical high impedance amplifier with voltage gain of 5, input impedance up to 4 megohms shunted by 1 mmf. Input resistances up to 100 megohms can be achieved by bootstrapping as in Fig. 5(d).

Practical design values and performance data will be given for a typical *a-c* high impedance amplifier of the general type discussed in this paper. The circuit is shown in *Fig. 7,* and contains bias arrangements of the simple type shown in *Fig. 5(b),* with the addition of R_8 to provide independent control of the operating current of transistor No. 1. With $R_8 = 10$ K as shown, the collector current of transistor No. 1 is about 0.3

ma. The collector current of No. 2 is stabilized at about 1 *ma*, and hence the voltage operating level of the No. 2 emitter is -10 *v*, and that of the No. 2 collector is -5 *v*. The common-emitter current-gains of the two transistors used were $\beta_1 = 75$, $\beta_2 = 64$. The effective *a-c* value of the bias resistor R_b is given by Eq. (17), or 40 K for the values shown in *Fig. 7;* hence it is expected that the positive feedback resistor should be $(R_2/R_1)R_b = 160$ K. Since fine adjustment is required, R_n suitably consists of a 120 K fixed resistor in series with a 50 K potentiometer.

The voltage gain of the circuit is $(R_1 + R_2)/R_1 = 4.9$, and was measured to be 5.0 at 1 *kc*. The gain was not noticeably less at 5 *cps*, and fell by 3 *db* at 1.3 *mc*.

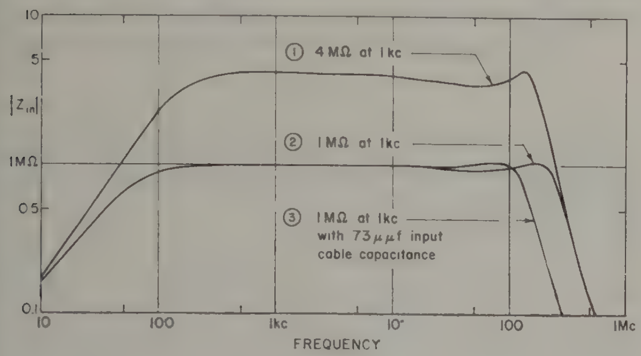

Fig. 8. Input impedance as a function of frequency for the circuit of Fig. 7.

The degree of stability of the voltage gain is expressed by the feedback factor F defined in Eq. (3), which is equal to 38 *db* for $\beta_2 = 64$. The magnitude of the input impedance, $|Z_{in}|$, is shown in *Fig. 8* as a function of frequency for various conditions. Curves 1 and 2 show $|Z_{in}|$ as a function of frequency when R_{in} at 1 *kc* is adjusted as described earlier to 4 megohms and to 1 megohm, respectively. It is observed that the high impedance is maintained to over 100 *kc* in each case, and the decrease in $|Z_{in}|$ at higher frequencies may roughly be ascribed to the presence of an effective shunt input capacitance of 1 *mmf*. Curve 3 shows $|Z_{in}|$ as a function of frequency when R_{in} at 1 *kc* is adjusted to 1 megohm in the presence of an input shielded cable with 73 *mmf* shunt capacitance. The equivalent input shunt capacitance is about 2 *mmf:* note that this is the apparent capacitance at the *input* of the shielded cable.

The decrease in $|Z_{in}|$ at low frequencies is caused by the 0.5 *mf* capacitor C in series with R_n and C_n. This was purposely made small in order to illustrate its effect. At first glance it would appear that $|Z_{in}|$ should be reduced by a factor of 2 at a frequency $f_o = 1/2\pi R_n C$; however, analysis shows that this frequency is actually $f_o = R_{in}/2\pi R_n C R_{in}'$, where R_{in} and R_{in}' are the midband input resistances with and without R_n present. Thus the effective time constant $R_n C$ is reduced whenever positive feedback is introduced to increase the input impedance. Substitution of numerical values $R_n = 160$ K, $C = 0.5$ *mf*, $R_{in}' = 40$ K $(\approx R_b)$ shows that f_o is about 50 *cps* for $R_{in} = 1$ megohm and about 200 *cps* for $R_{in} = 4$ megohms. These values are in reasonable agreement with the results of *Fig. 8*. The high input impedance can, of course, easily be extended to lower frequencies by increasing C, or C can be omitted altogether with consequent degradation in *d-c* stability.

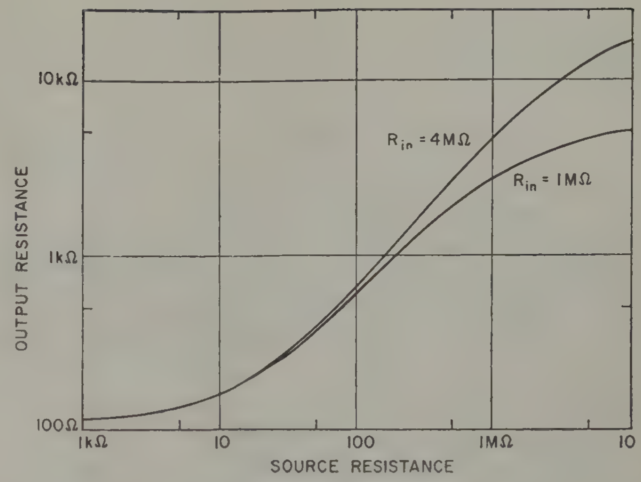

Fig. 9. Output resistance as a function of source resistance for the circuit of Fig. 7.

Figure 9 shows the output resistance R_{out} at 1*kc* of the circuit of *Fig. 7*, as a function of source resistance R_g. The presence of positive feedback to increase R_{in} also increases R_{out} at high values of source resistance; obviously if $R_g = 0$, R_{out} is independent of any positive feedback, and the predicted value is easily seen from *Fig. 4* to be $R_{out} = R_2/\beta_2$. The curves shown in *Fig. 9* were taken with a transistor No. 2 having $\beta_2 = 34$, thus $R_{out} = 3900/34 = 115$ ohms which agrees well with the measured results for $R_g \longrightarrow 0$. Although the output resistance is not large unless high values of source resistance are used, the output resistance can, of course, be reduced by addition of an emitter-follower stage to the output.

It is of interest to observe the effects of changing transistors on the operating points and on the input impedance in the circuit of *Fig. 7*. Table I shows the variations in the output *d-c* voltage V_o and in the input resistance R_{in} at 1 *kc* as transistors were changed. It can be seen that the operating point is well stabilized, but that re-adjustment of R_n would be necessary to maintain R_{in} constant.

TABLE I

β_1	β_2	V_0	R_{in}
75	64	5.0v	1.0MΩ
52	64	4.6	0.8
75	34	5.0	0.6
52	34	4.5	0.5

It is impractical to try to adjust the input resistance to more than about 100 times the effective *a-c* value of R_b, hence in the practical circuit of *Fig. 7*, 4 megohms is about the highest input resistance which can be achieved with reasonable stability. However, if bootstrapping is employed much higher input resistances can be achieved with the same basic circuit. For example, if the 300 K and 47 K bias resistors of *Fig. 7* are replaced by the bootstrap circuit of *Fig. 5(d)* in which $R_3 = 27$ K, $R_4 = 150$ K, and $R_{13} = 47$ K, then the effective *d-c* value of the bias resistor R_b is little greater than in *Fig. 7*, but the effective *a-c* value is greatly increased to the value given by Eq. (21). For a *d-c* bias current $I_e = 0.3$ *ma*, $\beta_2 = 50$, $R_1 = 1$ K, the resistance r is 80 ohms and $(1 - G') = 0.0017$ by Eq. (22). Hence $R_b|_{ac} = 47 \text{ K}/0.0017 = 28$ megohms. Since $\beta_1\beta_2 R_1 = 6$ megohms for $\beta_1 = 120$, it is obvious that the shunting effect of $R_b|_{ac}$ is quite small and the input resistance in the absence of positive feedback should be approximately 6 megohms shunted by the collector resistance of transistor No. 1. Direct measurement using transistors with values of β given above yielded an input resistance of 3.2 megohms. Addition of positive feedback (a value $R_n \approx 12$ megohms was required) produced stable input resistances up to 100 megohms.

No noise measurements were made on the particular circuits mentioned above, but it was noted that if R_8 in *Fig. 7* were omitted, the collector current of transistor No. 1 fell from 0.3 *ma* to 20 μa, and the noise output power with the input open-circuited, and without positive feedback, fell by more than an order of magnitude. At the same time, the input resistance without positive feedback fell from 3.2 megohms to 1 megohm, these results being in agreement with the theory presented earlier.

D-C High Impedance Amplifiers

The principles outlined in the previous sections may be extended to *d-c* amplifiers by the addition of a third transistor.

One possible basic arrangement is shown in *Fig. 10*. By proper choice of component values, both the input and output may be set at ground level for zero signal. Both positive- and negative-going signals can be accommodated. The voltage gain is $(R_1 + R_2)/R_1$, and the input admittance Y_{in} is

$$Y_{in} = \frac{R_1 + R_2 + R_9}{\beta_1\beta_2 R_1 R_9} + Y_i - \frac{R_2}{R_1} Y_n \tag{31}$$

where Y_i and Y_n are as defined in *Fig. 4* and have the same significance in *Fig. 10*.

Another possible arrangement of a high impedance *d-c* amplifier is shown in *Fig. 11*. This circuit differs from that of *Fig. 10* in that transistor No. 2 is in common-collector instead of in common-emitter connection, and to maintain correct phase relationships the base drive for No. 2 must be derived from the collector of No. 3 instead of from that of No. 1. The voltage gain is again $(R_1 + R_2)/R_1$, and the input admittance is

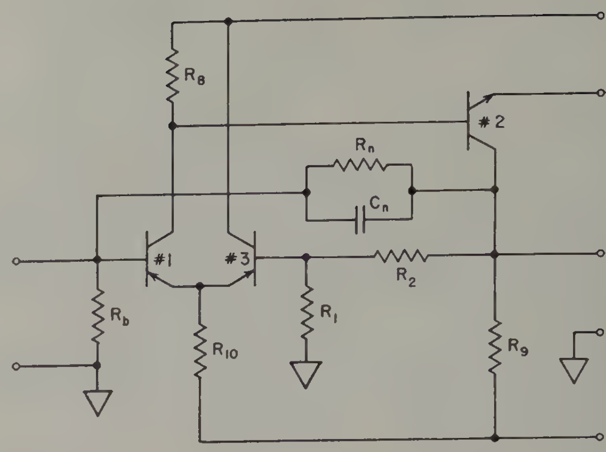

Fig. 10. One form of high impedance *d-c* amplifier. Both input and output can be set at ground level.

$$Y_{in} = \frac{R_1 + R_2}{\beta_1 R_1 R_8} + Y_i - \frac{R_2}{R_1} Y_n \tag{32}$$

The relative merits of the circuits of *Figs. 10* and *11* are as follows. In *Fig. 11*, the output can not be set at zero *d-c* level, unless the output is taken from the junction of R_1 and R_2 instead of from the emitter of transistor No. 2, in which case the voltage gain is unity. The first term on the right-hand side of the equation for the input admittance is larger for the circuit of *Fig. 11* than for that of *Fig. 10*, hence a greater degree of positive feedback through Y_n is necessary to attain a given input admittance. In the circuit of *Fig. 11*, all the transistors are of the same type, and also the phase shift within the feedback loop is less than in the circuit of *Fig. 10*, and hence greater stability results.

Only a brief description of the principles of high impedance *d-c* amplifiers is given here, since a detailed treatment of the design of *d-c* amplifies is beyond the scope of this article. Suitable bias stabilization techniques[11] must be applied, and drift compensation circuits[11] must be included if low signal levels are to be handled. It may be noted, since it is not possible to design separately for bias and signal conditions, that there are fewer degrees of freedom in design; in particular, the effective *d-c* and *a-c* values of the bias resistance R_b are inevitably the same, hence bootstrapping is of little value. Furthermore, since a blocking capacitor in the positive feedback path is not permissible, the bias stability is degraded below that obtained in the absence of postive feedback.

Conclusions

Principles of transistor amplifiers have been described which employ both negative and positive feed-

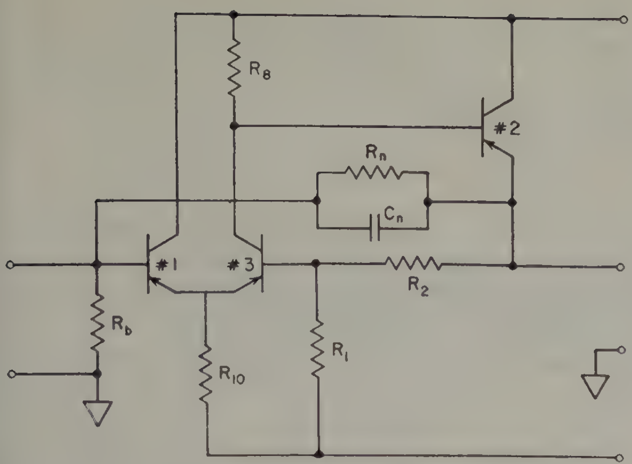

Fig. 11. Another form of high impedance *d-c* amplifier. Output can not be set at ground level except with unity voltage gain.

back, with greater-than-unity loop gain, to realize high input impedance wth good bias stability. Two-stage *a-c* amplifiers and three-stage *d-c* amplifiers are described which exhibit input impedances of the order of megohms shunted by one or two micromicrofarads. *A-C* bootstrapping enables input resistances in the order of 100 megohms to be realized with the same degree of bias stability. Other desirable features are that input shunt capacitance, such as that of a shielded cable, can be almost completely eliminated, the voltage gain is greater than unity and is stabilized, and the output impedance is low for low source impedances. Noise performance is discussed, mainly for the purpose of clarifying the common misconception that the optimum source resistance for minimum noise figure is directly related to the input resistance. Some criteria for realizing best noise performance are mentioned. Typical practical measurements are given, and various illustrative circuits are shown for both *a-c* and *d-c* amplifiers.

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Transistorized Entertainment Type FM Receivers*

HARRY COOKE**

Since the introduction of the transistor radio in 1954, we have seen transistors taking over a larger and larger segment of the entertainment radio market. Within the next year, it is probable that all but a very small percent of the portable and small table model *am* radios will be using transistors. This trend cannot be explained solely on the basis of the electrical advantages which transistors offer. Possibilities for changes in styling, size, and novelty also contribute to the rapid changeover to transistors. In the coming year we can expect *fm* receivers to follow this trend.

FROM A TECHNICAL point of view, the fully transistorized *fm* receiver was realizable several years ago, but the cost aspect was effective in preventing any release of such a receiver. As a matter of historical interest, *Fig. 1* shows the front end of an *fm* receiver built about two years ago using the grown diffused tetrode. The circuitry is conventional possibly with the exception of the *agc* transistor which is simply a *d-c* amplifier. The *r-f* amplifier has a net power gain of 15 *db* and the mixer 10 *db*, giving a total tuner gain of 25 *db*. The noise figure of this particular receiver is 12 *db*.

Figure 2 is taken from the same receiver and shows the *i-f* amplifier which has a gain of 60 *db*. The transistors are selected grown diffused triodes. At the time these transistors were introduced, the receiver would have had a transistor kit price of nearly $80.00.

The foregoing figures were quoted to suggest those factors which might be important in determining whether transistors can be used in an *f-m* receiver. As a comparison, we can now look at some figures on the diffused base transistors in a similar application and later in an actual receiver.

Referring to *Fig. 3*, and examining first the gain column, we see that the diffused base 10 *mc* gain is much higher than that of the grown diffused unit. The gains at 100 and 215 *mc* have been arbitrarily set at the 15 and 10 *db* levels because of the inevitable dollar vs. *db* relationship at higher frequencies. With the gains quoted, the total noise figure of cascaded stages will not be degraded significantly.

In the second column, it will be noted that noise figure has dropped considerably—by 5 to 6 *db* at 100 *mc*. The lowering of the base resistance in the diffused base unit is probably the most significant factor here.

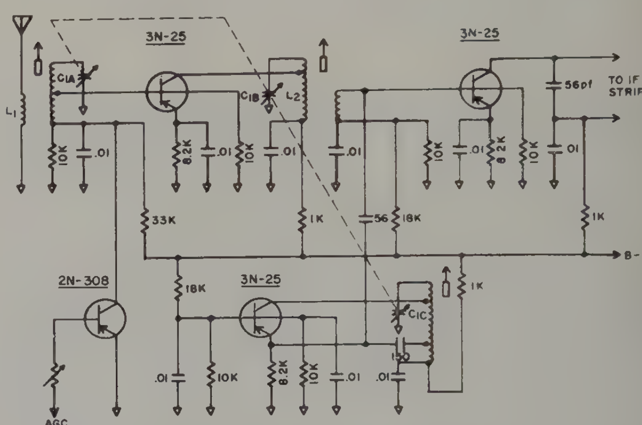

Fig. 1.—Front end of an early transistorized *fm* receiver using the grown diffused tetrode.

The last column is a projected price level aimed at the market for the coming year. The prices are not at this level as yet, but it is expected that transistorized TV will contribute to a general lowering of the prices of *vhf* type transistors. This table is intended to emphasize the principle factors governing the use of transistors in *fm*, namely: gain, noise figure, and price.

Three-Transistor Front End Design

We shall now examine some of the technical aspects of *fm* receiver design using transistors. This may be regarded as a state-of-the-art survey.

The actual front end can be classified by the number of transistors utilized; one, two or three. Larger numbers are possible but rather remote since the advantages of greater numbers are small. We will consider the three types in reverse order. *Fig. 4* shows a three-transistor tuner. The input circuitry is a transitionally coupled, series-tuned network designed to give a ± 1 *db* bandpass from 88 to 108 *mc*. The reasons for using such an input circuit are several:

(a) Prealigned, cheap, low *Q* coils can be used.

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(b) Only two circuits remain to be tracked with the tuning capacitor.

(c) Due to the low-loaded Q and the consequent good unloaded-to-loaded-Q ratio, the losses in the input network are less than 1 *db*.

The first two points are fairly obvious and need not be emphasized unduly, but (c) is of utmost importance and will be covered in more detail. The input network for the grounded-cathode *r-f* amplifier is usually designed to present to the grid the so-called "optimum-source-conductance" for minimum noise figure. Since there is no significant power transfer, only voltage, the Q of the input need only be sufficiently high to give the required bandwidth. In the case of the grounded-grid amplifier, and also the transistor, the amplifying device has a very finite input impedance and a power transfer must take place. If the input bandwidth is very large (as in the case of most grounded-grid *r-f* amplifiers) the loaded Q of the input network is low and the losses can also be low.

In the case where the desired input bandwidth is narrow, say 1 *mc* out of a band center frequency of 100 *mc*, the loaded Q is 100. It is not usually practical to build coils in quantity with Q's exceeding 150 at 100 *mc*. If this value is used, the ratio of $Q_u/Q_l = 1.5$. The efficiency of a coupling network can be shown to be equal to:

$$\eta = \left(I - \frac{Q_l}{Q_u} \right)^2$$

For the sake of convenience, this can be expressed in *db*'s in which case the efficiency becomes a minus number.

Figure 5 shows a plot of Q_u/Q_l vs. loss in *db*'s. The input coil design which we previously looked at with a Q_u/Q_l ratio of 1.5 has a power loss of 9.6 *db!* When we consider that this loss must be added directly to the input noise figure, it is obvious that such a circuit is not practical. The input coils of the front end design previously shown had loaded Q's of 7.0 and unloaded Q's of 70. With this ratio the loss per coil is approximately 0.1 *db*. This point cannot be stressed sufficiently if it is desired to realize good noise figures using transistors.

Referring now again to *Fig. 4*, the three-transistor front end, we note that the *r-f* amplifier is operated in the common base configuration. At frequencies approaching the alpha cutoff of a transistor, it is usually advantageous to operate the transistor common base for best gain. It would be possible to operate a transistor with a higher alpha cutoff in the common emitter circuit, but it would require a better and more expensive transistor.

The mixer is connected common emitter with the oscillator voltage being injected into the emitter. It is characteristic of the diffused base transistor that very

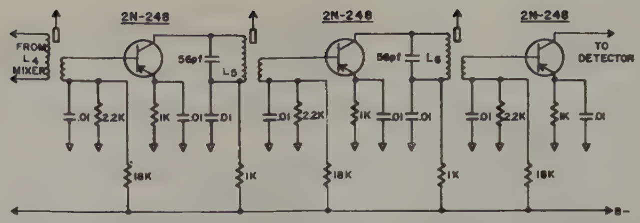

Fig. 2—*I-F* amplifier of the receiver referred to in Fig. 1. Selected grown diffused triode transistors are used.

Type Transistor	Frequency	Gain	Noise Figure	Price Range
Diffused Base "A"	215 mc	10 db+	9-11 db	$2 - $8
Diffused Base "B"	100 mc	15 db+	6- 7 db	$2 - $5
Diffused Base "C"	10 mc	30 db	5 db	$1 - $2
Grown Diffused 3N25	100 mc	10 db	12 db	$25.00 *
Grown Diffused 2N248	10.7 mc	15 db	-------	$ 3.00

* Price at time of introduction 2-1/2 years ago.

Fig. 3—Table of factors governing the use of transistors in *fm* receivers.

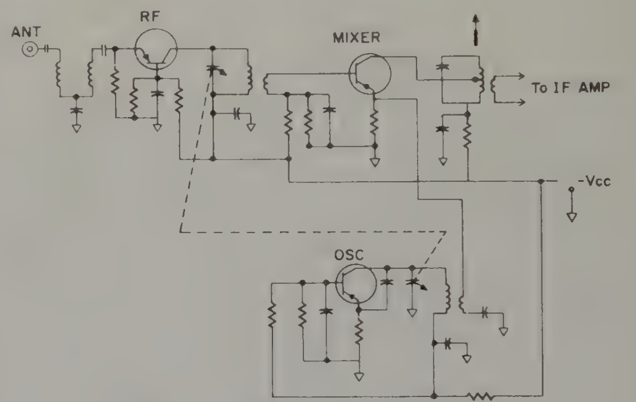

Fig. 4—Three-transistor tuner.

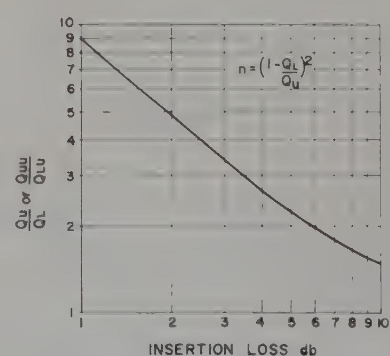

Fig. 5—Plot of the ratio of unloaded to loaded Q vs loss in *db*.

low transition capacities are possible, and consequently very good conversion power gain (10-20 *db*). Similar gains are also possible at 215 *mc* with this transistor. Gain, of course, is also a function of the intermediate frequency.

The oscillator is connected in the familiar two-terminal common-base circuit. Oscillation is assured by the addition of an external 2.2 *mmf* capacitor between the collector and emitter. High side injection is used.

Two-Transistor Front End Design

Figure 6 is the schematic of a two-transistor front end design. The *r-f* amplifier is operated as previously, but the mixer has become a converter with the addition of the tank circuit coupled to the emitter. In order to maintain a low impedance to the oscillator frequency for the return of the tickler winding, it may be necessary to use a series-tuned circuit across the primary of the first *i-f* transformer. This circuit is tuned to the mean oscillator frequency or approximately 104 *mc*.

Another possibility for the two-transistor front end is the oscillator-mixer combination. This is not shown since it is merely the three-transistor design with the antenna connected to the converter.

One-Transistor Front End Design

In *Fig. 7* are shown two possible configurations for a one-transistor front end. *Fig. 7A* shows a one-transistor front end with only one tuning element, the capacitor in the oscillator circuit. The front end is broad-banded, and therefore the intermediate frequency must be greater than 20 *mc* to maintain image rejection. *Fig. 7B* shows the same circuit, but with the input circuit tunable in order that a 10.7 *mc* *i-f* can be used. The unloaded Q of L_2 must be very high if the selectivity of the tuned circuit is to be high. One

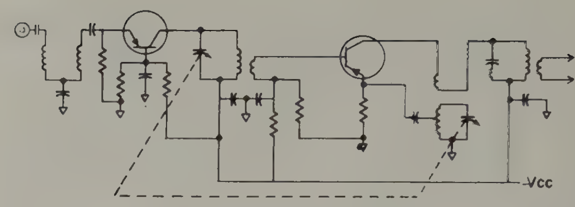

Fig. 6—Two-transistor front end.

solution to this problem is the use of short parallel lines which may have Q's of 300 or better.

A problem common to both of these circuits is that of oscillator radiation through the antenna terminals. Parallel tuned circuits are desirable in the input since they present a low impedance away from resonance. The balanced input is also quite effective in reducing radiation. Traps may be used providing their Q's are sufficiently high to prevent introduction of additional losses.

Neutralizing of converters is not generally necessary if the circuit impedances at the base and emitter can be kept low at the intermediate frequency.

I-F Amplifier Design

The *i-f* amplifier is now next to be considered. A minimum gain of 75 *db* is necessary to provide performance acceptable by today's standards. The grown diffused transistor shown earlier in the tetrode receiver has a gain of approximately 15 *db* at 10.7 *mc*. At least five stages would be required to give a net gain of 75 *db*. Actually, due to circuit losses, the gain would be nearer 65 *db* with typical transformers. With three diffused base transistors, a circuit net gain of 75 *db* is possible, 15 *db* being thrown away for stability purposes in coil loss and mismatch.

When considering bandwidth with a gain limited device such as a transistor, the limitation is not a gain-

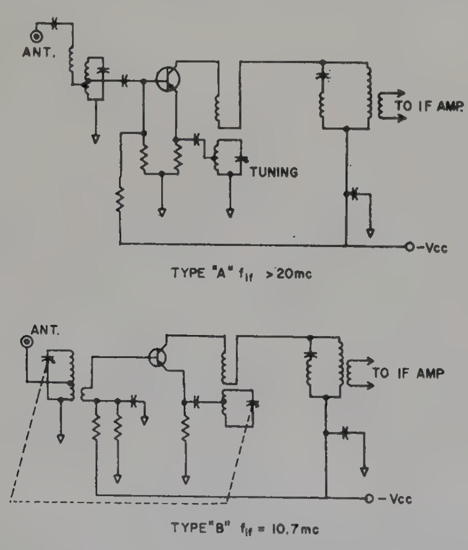

Fig. 7—One-transistor front ends.

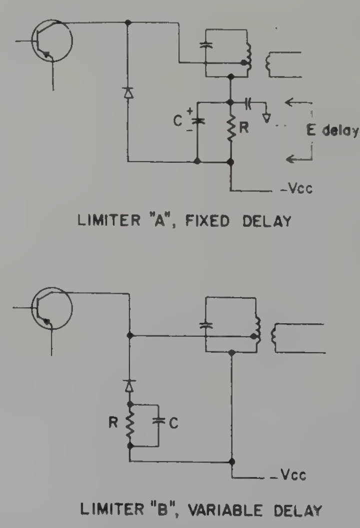

Fig. 8—Germanium diodes used for limiting in the *i-f* system.

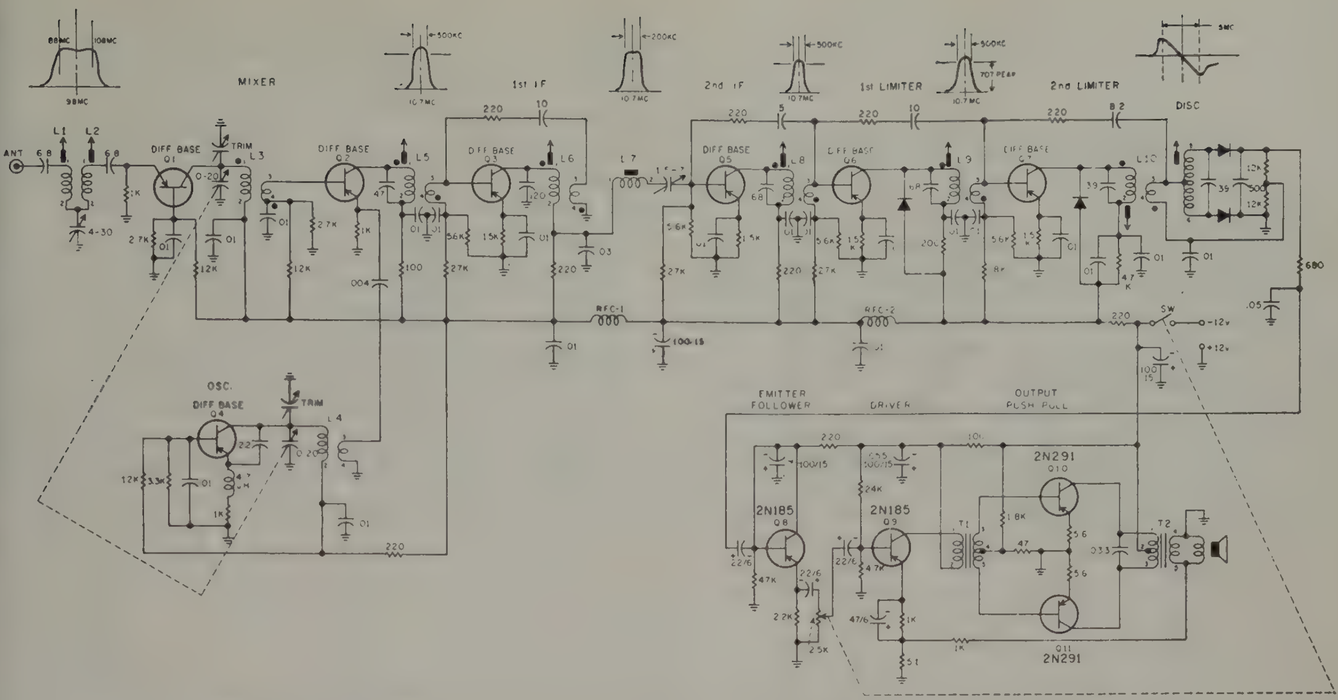

Fig. 10—Complete schematic of receiver using the design techniques discussed.

bandwidth product, but the Q of the transistor itself. In other words, almost any working Q is realizable, but the circuit losses may be so high as to be intolerable. This is the same story with the unloaded-to-loaded-Q ratio. If an *i-f* amplifier for 10.7 *mc* with a 3 *db* bandwidth of 160 *kc* is to consist of four double-tuned circuits, the bandwidth of each circuit will be 242 *kc*. This is an operating Q of $10.7/.242 = 48.5$ which, when used with an unloaded Q of 100, means a loss of 4.8 *db* per transformer or a total loss of 19 *db*. If the ouput of the transistor is mismatched for stability, there will be an additional loss. Whether these losses are tolerable depends on the transistor gain and the gain which which must realized from the circuit.

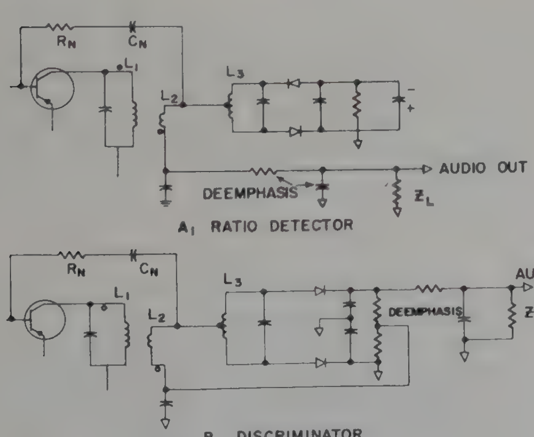

Fig. 9—Detector circuitry.

As a compromise on the loss problem, it is possible to use one double-tuned transformer with the net bandwidth required and the remainder of the circuits single-tuned with minimum loss bandwidth. In this case, the double-tuned transformer would have a loss of 8.5 *db* and the other three transformers, 0.1 *db* each. This gives a total loss of about 9 *db*, or 10 *db* better than the last example.

Limiting in a transistorized *i-f* system is usually obtained with germanium diodes as shown in *Fig. 8*. Circuit "A" has a fixed delay derived from the voltage drop across the collector decoupling resistor, but has the disadvantage that its time constant cannot be adjusted without considering the *IR* drop to the collector. Circuit "B" has a separate diode load resistor, and is actually an impulse type limiter. The optimum delay voltage for each diode is a function of the stage gain following it and is best set by empirical methods to obtain the best overall performance. *AGC* can also be derived from the limiter in circuit "B."

Detector Design

The choice of the type of detector used with the receiver is still dictated by the considerations in the vacuum tube counterpart, i.e., limiting, downward modulation, *agc*, sensitivity, etc.

The ratio detector design shown in *Fig. 9A* varies from its vacuum tube counterpart in two principle considerations. First, the loaded Q of L_1 is determined by both the transformed diode load and the output impedance of the *i-f* transistor. Secondly, the loading provided by the input to the audio amplifier is no

longer insignificant and must be considered when determining in the loaded Q of L_3.

The tertiary winding, L_2, is a convenient means of matching the output impedance of the driving transistor to the transformed load. If the sense of L_2 is reversed, relative to L_1, this winding may also be used for neutralization.

The discriminator shown in *Fig. 9B* is also conventional except that a tertiary winding is used rather than a capacitor to obtain the primary reference voltage. This also provides for matching the secondary load to the transistor output.

In both of the detector circuits shown, it is possible to use audio loads of 1000 ohms or less and still obtain an impedance match to the collector of the driver at a given signal level. However, it is sometimes advantageous to have the diodes operate into a higher audio impedance in order to reduce low level distortion. An emitter-follower is quite useful in this function since the load impedance is roughly multiplied by the beta of the emitter-follower. The last *i-f* stage can sometimes be reflexed to perform the function of emitter-follower, thus saving an additional transistor.

The audio system to be used with any particular receiver design will vary, and is beyond the scope of this paper, but it is likely that the first receivers will have audio outputs in the .5 to 1.0 watt class.

Figure 10 is the schematic of an *fm* receiver utilizing the techniques set forth above. The receiver has a threshold sensitivity of a 2 μv and is completely limited at the 4 μv level. The *i-f* bandwidth is 200 *kc* and the discriminator has a 500 *kc* peak separation.

Dislocations In Crystals

J. R. PATEL*

Many important properties of crystals are determined by the imperfections present in them. One important class of structural imperfections are dislocations. The geometry of a simple edge dislocation is described in this article. The various means of detecting and studying such imperfections are outlined with special reference to the semiconductor elements silicon and germanium. While the density of dislocations in these semiconductors is low compared to the values quoted for metals, their electrical effects are quite marked.

THE FACETED geometrical forms in which many crystals, both natural and artificially grown, occur are familiar to most of us. The external symmetry of crystals suggests that the atoms which constitute them are also arranged in some definite pattern. Suppose, for instance, that the atoms of which the crystal is built up lie at the corners of a cube. If this elementary cube is then repeated in three dimensions, it would, after many thousands of repetitions, build up a crystal large enough to be seen under a microscope or by the unaided eye. A perfect crystal would be one in which we would expect to find an atom at all the corners of the cubes in the crystal. Experience, however, suggests that perfection is rarely achieved. Instead, one normally expects to find occasional corners where the atoms are either missing or have their places occupied by an atom of another species. Indeed, depending on the conditions under which the crystal grew, a group of atoms or a large section of a plane or sheet of atoms might be missing. As may be readily imagined, such disturbances in the lattice destroy its perfect regularity, and we may regard these areas of the crystal as being "bad" regions. It is quite generally recognized that certain properties of crystals are extremely sensitive to the "bad" regions or imperfections present in them. We shall confine our attention here to one particular class of imperfections called dislocations. As we will explain later in somewhat greater detail, a dislocation in a crystal is formed when a section of a plane of atoms is missing.

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Dislocations and Strength of Crystals

Before a detailed geometrical description is attempted, it is instructive to see how the idea of dislocations in crystals first originated. We know that most crystals will deform plastically when a suitable load or stress is applied. This process of deformation is very similar to that of sliding a pack of cards over one another, i.e., the crystal deforms by a sliding or gliding of the planes of atoms. It is evident that if the

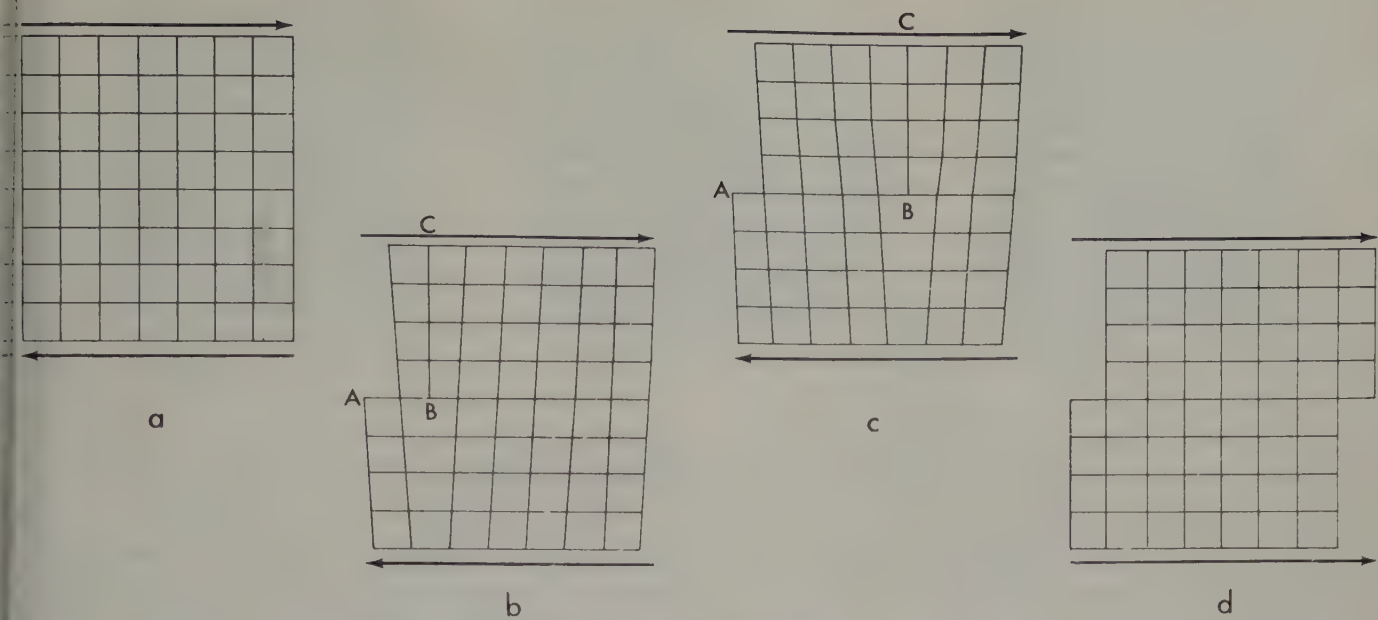


Fig. 1—Movement of an edge dislocation through a crystal.

plane of atoms is to glide, the interatomic forces that bind it to the neighboring plane must be overcome. Since these interatomic forces were theoretically about a thousand times larger than the stresses actually required to deform the crystals, a serious discrepancy between theory and experiment confronted the scientist 25 years ago.

To resolve this dilemma, a completely new concept regarding the nature of plastic flow in crystals was necessary. In 1934 it was hypothesized that plastic flow in crystals occurs by the movement of dislocations. The simplest type of dislocation postulated may be visualized with reference to *Fig. 1.* If a shearing force is applied to a crystal in the direction of the arrows, deformation may begin gradually over a part of the crystal. Over the left side of the crystal, AB, slip has occurred by one unit step. Since this slip step has not yet appeared on the right, it is obvious that the top half of the crystal will contain a plane of atoms BC not in registry with those below. The edge of the extra half plane (perpendicular to the plane of the schematic) is called an edge dislocation. The movement of this extra half plane of atoms or dislocation line through the crystal will eventually, if it keeps moving, leave a step on the right hand side of the crystal, similar to that at A. Hence, if a dislocation is formed on one side of a crystal and moves all the way through it, the same result is achieved as if the two halves of the crystal were to glide rigidly over one another. It may be shown that the stress required to move such a dislocation (at least in metals) is very small, so that plastic deformation may be observed at stresses well below the theoretical value.

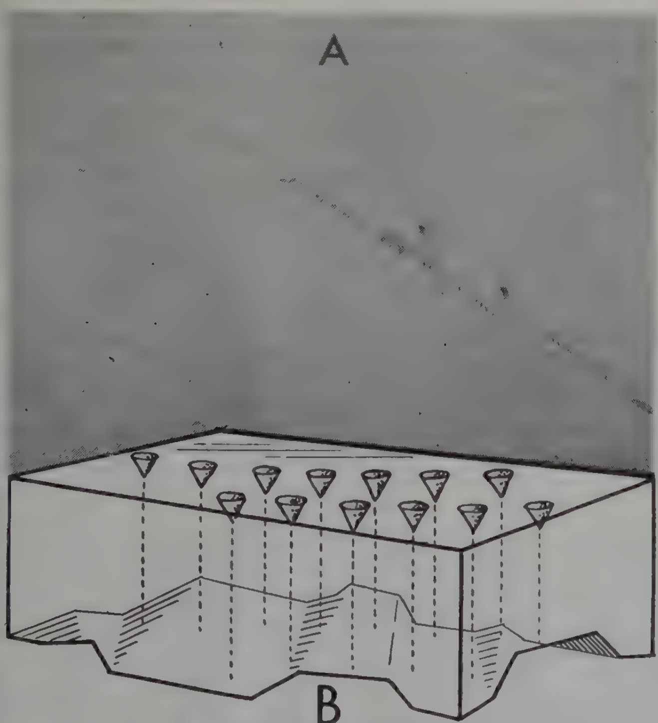
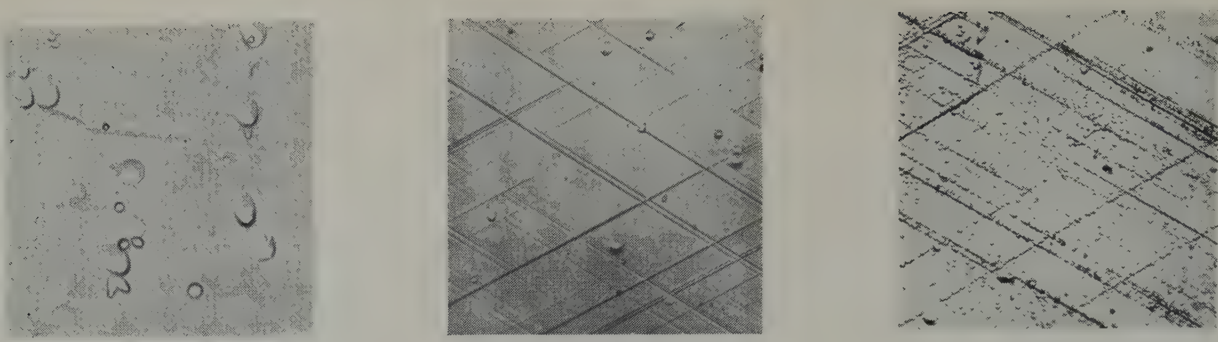


Fig. 2—Etch pits at dislocations in germanium.

Until very recently, most of the evidence for dislocations was indirect, since techniques for the observation of their detailed characteristics were lacking. However, in the last few years a very large body of information has accumulated to provide a sound experimental verification of the theoretical hypotheses of dislocation theory. The semiconductor elements germanium and silicon have played an important role in this development, and it is with these that we will be mainly concerned here.

Etch Pits Due to Dislocations

One important technique for the observation of dislocations arises from the action of suitable chemical



(before deformation) (after deformation) (after etching)

Fig. 4—Germanium crystal. Before deformation (left); after deformation (center); after etching (right).

solutions on polished crystal surfaces. When single crystals are etched in appropriate solutions, one may, under favorable circumstances, observe two distinct types of etch pits. One type is characteristic of the crystallographic nature of the plane under observation, and is generally a well defined geometrical figure, while the other is caused by linear imperfections present in the particular piece of material.

Vogel and his co-workers were the first to notice a certain type of etch pit on germanium that did not behave in a manner similar to the characteristic etch figures. It was noticed, for instance, that pits of the type shown in *Fig. 2A* preserved their geometrical arrangement even after the surface was ground off and re-etched, whereas the characteristic etch pits are random and cannot be followed through successive etching. The inference from this is that the pits were

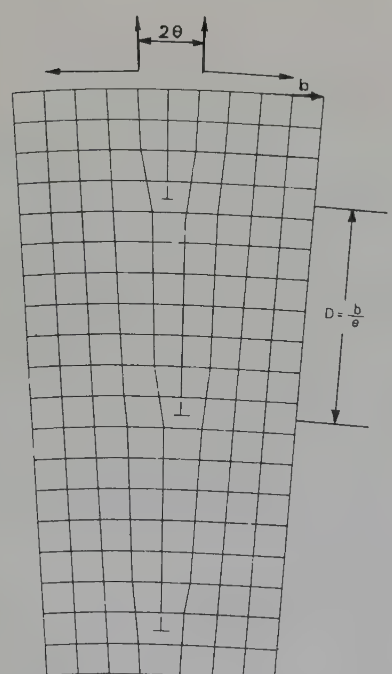


Fig. 3—Burger's model of a low angle boundary.

due to some kind of linear imperfection running through the crystal. *Fig. 2B* shows the manner in which pits due to dislocation lines may be observed on a crystal face. The lines running through the crystal represent dislocations. After suitable etching, pits are formed where the lines intersect the surface. Since the region around a dislocation line is highly strained or disturbed, it may be expected that this region will etch differently from other parts of the crystal where strains are considerably lower. If these pits are indeed due to dislocations, an array of the type shown in *Fig. 2A* should result in a low angle boundary where the two parts of the crystal are slightly tilted with respect to each other. As shown schematically in *Fig. 3*, an array of dislocations accommodates the misfit in the region where the two crystals meet. For small angles of tilt, θ equals b/D (Burger's formula), where b is the interatomic distance and D the distance between the dislocations. By measuring the distance between etch pits such as shown in *Fig. 2* and by measuring the angle of tilt between the two parts of the crystal by X-ray methods, close agreement was obtained by Vogel between the angle calculated from Burger's formula and the angle measured by X-rays.

Additional evidence that etch pits are due to dislocations can be obtained from germanium and silicon crystals subjected to plastic deformation. In order to account for the large amount of slip observed on the active slip planes of deformed crystals, dislocation theory postulates the operation of a multiplication mechanism by means of which large numbers of dislocations are produced during deformation. Many of these will pass out of the crystal, resulting in observable slip lines or steps on the crystal surfaces. (See *Fig. 4*.) However, a large number will be trapped in the deformed crystal and should be observable as etch pits along the slip lines. The density of the etch pits (as revealed by counting at high magnification) is found to be about three orders of magnitude greater than the density observed in the same crystal before deformation.

Quantitative measurements on the number of dislocations introduced by deformation may best be accomplished by plastic bending. A simple formula,

$N = 1/Rb$, derived by Cahn on the basis of a model in which dislocations of the same sign give rise to bending, shows the theoretical relation between the number of dislocations, N, introduced into a bent sample as a function of the radius of curvature, R, where b is Burger's vector or the interatomic distance. We notice that as the radius of the bend gets smaller, the number of dislocations in the sample rapidly increases. If now by bending suitably oriented crystals to different radii of curvature, we obtain the type of dependence of dislocation density with radius predicted by the formula, we may consider this as good statistical proof that the pits observed are in fact due to dislocations.

To verify the bending formula, however, it was first found necessary to anneal the deformed sample so that the macroscopic internal stresses introduced after deformation are removed. In general, it was noticed that the average dislocation density was higher than the predicted values after deformation, and it was only after prolonged annealing at elevated temperatures that the density was reduced and the theoretical values approached. The etch pit configuration on a bent silicon crystal before and after annealing is shown in *Fig. 5*. The decrease in density after annealing is noticeable. One can also see that the pits in the annealed sample are now lined up perpendicular to the original slip lines. This illustrates the phenomenon known as polygonization which occurs simply because the energy of the array shown in *Fig. 5B* is less than the one in *Fig. 5A*. Similar results have been shown for germanium by Vogel.

Direct Observation of Dislocation Lines in Crystals

The etch pit technique for observing dislocations is, however, by its very nature limited. For instance, it tells us only where the line of the dislocation intersects a surface; it does not tell us what the geometry of this line is inside the crystal. For this, one has to look into the interior of the crystal itself. In transparent crystals this is possible by ordinary light microscopy, and early investigators did observe networks of dislocation lines in silver bromide crystals.

For silicon, which is opaque to ordinary light, but transparent to infrared, this type of observation would

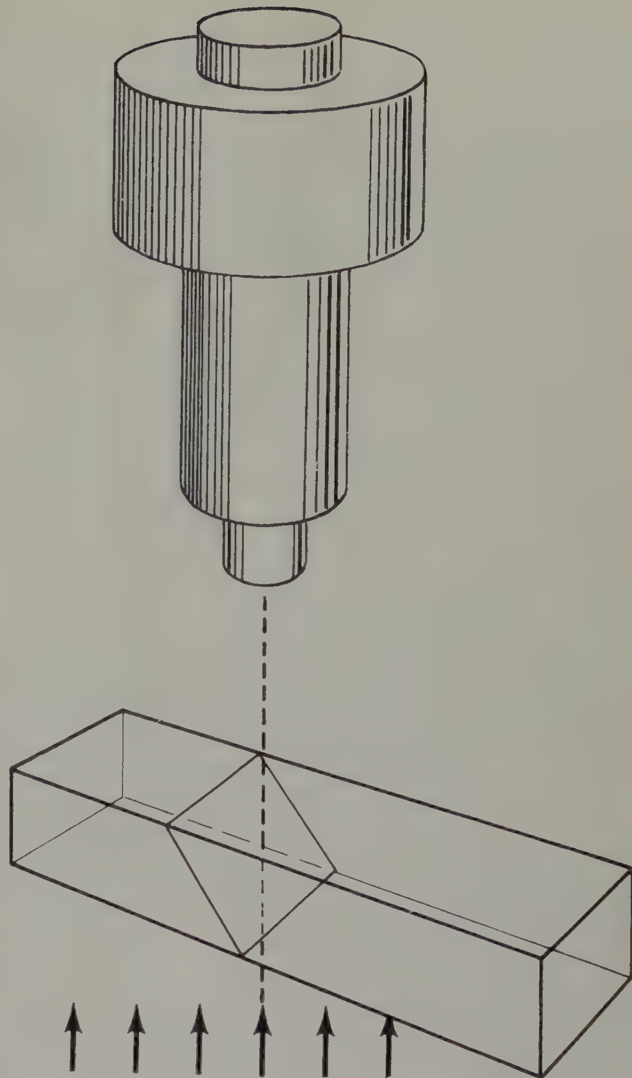
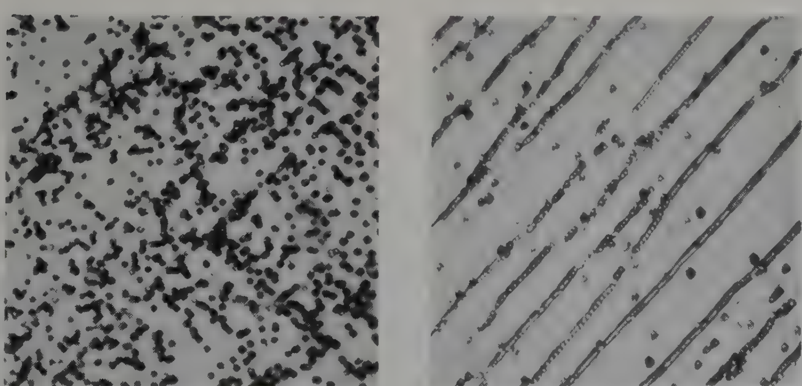


Fig. 6—Method of examining silicon crystals by transmitted infrared.



A—Before annealing **B—After annealing**

Fig. 5—Etch pits in bent silicon.

Fig. 7—Copper precipitation at dislocations in silicon.

be possible if a means could be devised for observing the transmitted infrared radiation. Such observations were first made by Dash, who used an infrared image converter tube, commonly referred to as a snooperscope, to actually observe the interior of silicon. The scheme of observation is shown in *Fig. 6*. Infrared radiation is transmitted through silicon, and the transmitted beam is collected by the microscope objective. Instead of an eyepiece, one uses an image converter tube, which converts the infrared image to one that is visible to the human eye. Dislocations would still not be visible if an untreated piece of silicon were observed under an infrared microscope. Dash, however, has shown that by diffusing the samples with copper at an elevated temperature and quenching, dislocation lines can be revealed because the copper, which is opaque to infrared, precipitates on them in a preferential manner, and so delineates them.

Figure 7 shows a pattern of lines observed on an "as grown" crystal of silicon. The patterns shown are dislocation loops that are formed during the actual growth of the crystal. As can be readily seen, the technique is a powerful one for investigating the way in which dislocations may be introduced during crystal growth, or after plastic deformation. Unfortunately, transmission in germanium begins further out into the infrared (1.8 microns), and there are no simple methods for the direct observation of the interior of a germanium sample.

Effects of Dislocations On Semiconductors

One of the interesting facts emerging from these studies on semiconductors is that the density of dislocations in carefully grown crystals is surprisingly low, being of the order of 10^4 dislocations/cm^2 or less. This is four orders of magnitude smaller than the estimate of 10^8 dislocations/cm^2 arrived at indirectly from an analysis of the mechanical properties of annealed metal crystals. X-ray measurements of such germanium crystals also show that the perfection is indeed closely approximated. However, although the number of these imperfections is comparatively small, their effects on the electrical properties of semiconductors are quite marked. It has been shown in germanium that varying the dislocation density affects the "lifetime" (the time during which minority carriers exist before they recombine with carriers of the opposite sign). Indeed, a small increase in dislocation density may reduce the lifetime to a negligible value. Low angle boundaries of the kind shown in *Fig. 2* are also to be avoided because of their deleterious effects on device fabrication during etching and alloying.

While the visual observation of etch pits has aided greatly in the study of the effects of dislocations on electrical properties, our understanding of these is far from complete. Many of these results are fairly recent and much work remains to be done. Such studies, however, have not only aided our understanding of the effect of dislocations on semiconductors, but should permit us to further our understanding of their effects in other materials as well.

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(4) Fisher-Johnston-Thompson-Vreeland, "Dislocations and Mechanical Properties of Crystals," John Wiley & Sons, Inc., New York, 1957.

PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications July 28, 1953 to Jan 26, 1954

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from July 28, 1953 to Jan. 26, 1954. In subsequent issues, patents issued from Jan. 26, 1954 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear every three months, the treatment given to each item being more detailed.

July 28, 1953

2,647,226 Dry Rectifier Valve Plate—A. Arvidsson. Assignee: Allmanna Svenska Elektriska Aktiebolaget (a Swedish Corporation). A dry-rectifier plate comprising metallic base plate, a semiconducting layer thereon, a counter-electrode covering the major portion of the semiconductor, and an insulating layer in contact with the central portion of the semiconducting layer.

2,647,227 Dry Plate Rectifier—W. M. Lacey. Assignee: Sylvania Electric Products Inc. A dry plate rectifier comprising series-connected multiple plates, each having a counter-electrode, a carrier electrode, and an intervening rectifying layer, the construction being such as to cause the counter-electrode of one plate to overlap the carrier electrode of the next plate.

August 4, 1953

2,647,957 Transistor Circuit—C. O. Mallinckrodt. Assignee: Bell Telephone Laboratories. In a transistor circuit, means for applying an emitter bias current of the order of 0.3 *ma* so that the objective of providing constant current emitter bias without introducing undesirable factors is achieved.

2,647,958 Voltage and Current Bias of Transistors—H. L. Barney. Assignee: Bell Telephone Laboratories. Signal translating apparatus consisting of a three terminal transistor, means for applying the potential of a source as an operating voltage bias to the collector, means for deriving a constant current from the source, and means for supplying constant current to the emitter.

August 11, 1953

2,648,805 Controllable Electric Resistance Device—E. H. Spenke, F. W. Rose, E. G. Waldkotter. Assignee: Siemens-Schuckertwerke Aktiengesellschaft (German). A device comprising a resistance body of barrier-layer forming material forming a current path and having a spot of constricted conductance in said path, and a barrier electrode joined with said body around said spot.

August 18, 1953

2,649,409 Electrodeposition of Selenium—A. von Hippel, M. C. Bloom. Assignee: Federal Telephone and Radio Corp. A process that involves producing on a metal surface a coating of a selenide of the metal, and then treating the object as the cathode in an 18 normal aqueous solution of sulphuric acid at a temperature between 55°C and 120°C.

2,649,410 Electrodeposition of Selenium—M. C. Bloom, J. P. Levy. Assignee: Federal Telephone and Radio Corp. A process of regenerating an acidic aqueous selenium dioxide electrolytic bath contaminated with organic matter by adding thereto elemental selenium in a quantity greater than the normal metallic selenium content of said bath.

2,649,560 Motor System for Controlling Pressure—R. R. Blair. Assignee: Bell Telephone Laboratories. In combination, a semiconductor element, a conductive element, means for bringing the elements into contact and for increasing the contact pressure, and means for stopping the contact driving apparatus when the elements have been in contact for a predetermined period.

2,649,569 Semiconductor Magneto-Resistive Device—G. L. Pearson. Assignee: Bell Telephone Laboratories. The method of measuring the strength of a magnetic field which comprises inserting a single semiconductive crystal in the field with the crystal axis of the body parallel to the field, passing a constant current through the body in a direction parallel to said axis, and measuring the voltage drop between two points on said body spaced along the axis.

2,649,574 Hall-Effect Wave Translating Device—W. P. Mason. Assignee: Bell Telephono Laboratories. In combination, a Hall-Effect unit comprising a body of semiconductive material provided with two sets of electrodes, an input supplying unmodulated carrier waves of at least 10 *kc*, and a control circuit to produce a magnetic flux that varies with a control current, thus causing the output circuit to receive the carrier waves which vary in the same manner.

August 25, 1953

2,650,258 Semiconductor Photosensitive Device—J. I. Pantchechnikoff. Assignee: Radio Corporation of America. A germanium body embedded in its support, a light-transmitting film of metal on the exposed surface of the germanium, and an electrode in contact with said film.

September 1, 1953

2,651,009 Transistor Design—E. A. Meyer. Assignee: Bjorksten Research Laboratories. A transistor comprising two n-layers and between these a p-layer comprising a membrane adhered by surface tension to an annular conductor whose inner diameter is greater than the outer diameter of at least one of the n-layers.

2,651,020 Voltage Regulator—F. R. Milsom. Assignee: S. Smith and Sons, Furzehill Laboratories (England). The system provides a voltage regulator producing an output wave-form of low harmonic content with good regulation, and in which the output voltage is substantially unaffected by normal frequency variations.

September 8, 1953

2,651,728 Semiconductor Trigger Circuit—M. L. Wood. Assignee: International Business Machines Corp. A trigger circuit having two stable states of equalibrium and utilizing a triggering action that does not depend upon a regeneratvie or positive feedback circuit connection.

2,651,745 Dry Rectifier Assembly—S. H. Marrow. Assignee: International Standard Electric Corporation. An assembly consisting of a tube of insulating material, a stack of dry plate rectifiers inside the tube, and two flat contact washers, one of them in contact with the stack sandwiching a spiral spring.

September 15, 1953

2,651,831 Semiconductor Translating Device—W. L. Bond, M. Sparks, G. K. Teal. Assignee: Bell Telephone Laboratories. The method of preparing a rod of semiconductor material composed of two elongated crystals of n-type conductivity with an intervening sheet of p-type conductivity, and by said method melting a mass of n-type material, partly immersing in the melt a pair of elongated seed crystals of the material having a 10 degree difference in crystal orientation along the junction, and lifting the seed at the rate of solidification.

2,652,460 Transistor Amplifier Circuits—R. L. Wallace, Jr. Assignee: Bell Telephone Laboratories. A device which provides: an improved interstage coupling network for a multistage transistor amplifier, an efficient Class B push-pull translating circuit, and automatic adjustment of the emitter bias current of a transistor amplifier.

2,652,522 Rectifier Stack—A. S. Vanderhoof. Assignee: Federal Telephone and Radio Corporation. A rectifier stack assembly comprising a core of insulating material, a plurality of rectifying plates each having an opening therethrough, washers between certain plates, and resiliant lock nuts.

September 29, 1953

2,653,374 Electric Semiconductor—K. A. Matthews, C. De Boismaison. Assignee:

* Source Official Gazette of the U. S. Patent Office, and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

International Standard Electric Corporation. An electro-forming process for a crystal triode which comprises passing a relatively small direct current between the emitter and collector electrodes of the device and then momentarily increasing said direct current to a relatively large value.
2,654,059 Semiconductor Signal Translating Device—W. Shockley. Assignee: Bell Telephone Laboratories. A device comprising a semiconductive body having a pair of zones of one conductivity type and an intervening zone of the opposite conductivity type, and means for making electrical connections to the body whereby one connection consists of a gold containing conductor that physically straddles the junction between two zones.

October 13, 1953
2,655,607 Electric Delay Device Employing Semiconductors—A. H. Reeves. Assignee: International Standard Electric Corp. Means for deriving a delayed pulse from a second trigger circuit by having a first trigger circuit transmit a coupling pulse over a semiconductive surface which influences said second circuit to cause spontaneous operation after a delay that depends upon the separation of the electrodes on the semiconductor surfaces.
2,655,608 Semiconductor Circuit Controlling Device—L. B. Valdes. Assignee: Bell Telephone Laboratories. A circuit enabling accurate determination of the triggering voltage in transistor switching devices.
2,655,609 Bistable Circuits Including Transistors—W. Shockley. Assignee: Bell Telephone Laboratories. A pair of opposite type junction transistors are connected in a base to collector relationship, and in this configuration the combination constitutes an equivalent transistor having a current multiplication factor substantially greater than that of either of the component units.
2,655,610 Semiconductor Signal Translating Device—J. J. Ebers. Assignee: Bell Telephone Laboratories. A device that achieves a high current multiplication concomitantly with a low collector saturation current.
2,655,624 Multi-electrode Semiconductor Crystal Element—H. Welker. Assignee: Societe Anonyme dite: Compagnie des Freins et Signaux Westinghouse. A cylindrically shaped device whose cross section includes a concave portion the thickness of which measures between 1 and 500 microns, said device being contacted by electrodes that are free from barrier layer effect.
2,655,625 Semiconductor Circuit Element—E. T. Burton. Assignee: Bell Telephone Laboratories. A device comprising a body of semiconductive material including a zone of one conductivity type between a pair of zones of the opposite type, and means for dividing said body into a plurality of diodes associated in accordance with a preassigned circuit pattern.
2,655,626 Selenium Rectifier—R. J. Cepon. Assignee: Fansteel Metallurgical Corp. The method of production consists of providing a supporting electrode coated with crystalline selenium, wetting the surface with a solution of a permanganate salt, allowing a reaction to take place, and covering the treated surface with a counter electrode.

October 20, 1953
2,656,494 Blocking Layer Rectifier—R. Duval. Assignee: General Electric Company. An improved contact means for connecting together the two sides of blocking-layer type rectifier elements assembled in stacked relationship.
2,656,495 Spring Washer—C. S. Smith. Assignee: Syntron Company. A current collecting spring washer for use on dry disk rectifiers, said washer consisting of a flexible metal disk having a plurality of annular concentric shoulders.
2,656,496 Semiconductor Translating Device—M. Sparks. Assignee: Bell Telephone Laboratories. An electrolytic method for differentially removing material from regions of both conductivity types in order to produce a semiconductive element comprising adjacent regions of opposite conductivity type, the two regions being distinguished by a shoulder at their junction.

October 27, 1953
2,657,309 Storage Device Utilizing Semiconductor—F. Gray. Assignee: Bell Telephone Laboratories. A body of semiconductive material, a metallic contact electrode, a thin charge-sensitizing film containing a trace of carbonaceous material, and a means for applying a stream of charged particles to said film.
2,657,344 Rectifier Stack—P. T. O'Neil. Assignee: Federal Telephone and Radio Corporation. A plurality of rectifier disks having non-circular openings, a means for properly spacing and connecting adjacent disks, and a non-circular insulating shank supporting the assembled stack.
2,657,345 Transconductor Employing Line Type Field Controlled Semiconductor—O. M. Stuetzer. A transconductive device consisting of a body of semiconductor material, an output electrode having a thin layer of metal in contact with said body, closely spaced perforations in the metal layer, a layer of dielectric material upon the metal layer, and a layer-type input electrode.
2,657,360 Four Electrode Transistor Modulator—R. L. Wallace, Jr. Assignee: Bell Telephone Laboratories. A transistor device of *n-p-n* type construction having a normal collector and emitter electrode, and two base electrodes, said device having means for applying modulating signals to the auxiliary base connection whereby the modulation product of the input and modulating signals appears in the load.

November 17, 1953
2,659,271 Silicon-Germanium Objective Lens—R. G. Treuting. Assignee: Bell Telephone Laboratories. An objective lens for wavelengths in the infra-red comprising two axially aligned optical elements each of which is transparent to wavelengths in the infra-red and opaque to visible light, the first element composed of highly pure silicon and the second element consisting of highly pure germanium.
2,659,773 Inverted Grounded Emitter Transistor Amplifier—H. L. Barney. Assignee: Bell Telephone Laboratories. An amplifier consisting of a power source, a three terminal transistor, and output terminals connected between the collector and the emitter, said amplifier being characterized by an impedance of zero magnitude.
2,659,774 Bi-Directional Transistor Amplifier—H. L. Barney. Assignee: Bell Telephone Laboratories. The circuit provides substantial power amplification in each of two opposite directions of transmission, and supplies a load with a voltage which is dependent on an input signal voltage but is independent of the load impedance.
2,659,846 Selenium Element and Method of Making It—H. A. Rudolph, Assignee: International Rectifier Corporation. A selenium comprising a base plate, a selenium layer adhered thereto, a selenium barrier layer, a counter electrode, and still another barrier layer, each selenium layer having a halogen content.

November 24, 1953
2,660,624 High Input Impedance Semiconductor Amplifier—G. Bergson. Assignee: Radio Corporation of America. The device provides a multistage semiconductor amplifier having a high input impedance looking into the emitter, the output impedance of one stage matched to the input impedance of the succeeding stage, and having a balanced push-pull input circuit and an unbalanced or single-ended output circuit.
2,660,670 Peaked Voltage Circuit—W. H. Elliot. Assignee: Cutler-Hammer Inc. A circuit utilizing a semiconducting rectifier element in which alternating current passing through an electron tube provides voltage of peaked wave form across a resistive element.
2,660,696 Crystal Contact Device—E. G. James, A. O. Lindell. Assignee: Hazeltine Research Inc. An electrical crystal contact device comprising a body of insulating material and two prespaced parallel wires making point contact with a semiconductive crystal that is supported on a conductive support which maintains the insulator and the crystal in a fixed relationship.
2,660,697 Selenium Rectifier with Varnish Intermediate Layers—H. E. Lauckner. Assignee: International Standard Electric Corp. Selenium rectifier in which an intermediate layer of insulating material is placed between the semiconducting layer and the back electrode for an improvement in the blocking voltage.
2,660,698 Selenium Rectifier—D. W. Black. Assignee: Federal Telephone and Radio Corp. The intermediate layer between the selenium and the counter electrode consists of a high molecular weight linear polymeric carbonamide.

December 8, 1953
2,662,122 Two Way Transistor Electrical Transmission System—R. M. Ryder. Assignee: Bell Telephone Laboratories. A bilateral amplifier for transmitting signals with substantially equal power gains in a forward direction and in a reverse direction.
2,662,123 Electrical Transmission System Including Bilateral Transistor Amplifier—W. Koenig, Jr. Assignee: Bell Telephone Laboratories. One objective of this device is to provide a four-pole circuit in which the impedance looking into one pair of terminals is approximately the negative of the load impedance across the other pair of terminals.
2,662,124 Transistor Amplifier Circuit—B. McMillan. Assignee: Bell Telephone Laboratories. A circuit using two three-terminal transistors, said circuit being designed to provide improved impedance matching characteristics of certain types of transistor amplifiers.

December 15, 1953
2,662,957 Electrical Resistor or Semiconductor—P. Eisler. Assignee: None. A multilayer stack for manufacture of a plurality of resistors comprising an insulating support, at least one layer of a resistance material, and a layer of a highly conductive material adhering to the resistance material and in intimate contact therewith.
2,662,976 Semiconductor Amplifier and Rectifier—J. I. Pankove. Radio Corporation of America. A semiconductor system

comprising a body of semiconductive material, a large contact-area electrode, and three small area contact electrodes.

2,662,997 Mounting For Semiconductors—H. Christensen. Assignee: Bell Telephone Laboratories. In combination a semiconductor body and a metallic base member to which said body is bonded, said base member having a thermal coefficient of expansion of about the same value as that of said body over the temperature range to which the combination is subjected.

December 22, 1953

2,663,766 Transistor Amplifier With Conjugate Input and Output Circuits—L. A. Meacham. Assignee: Bell Telephone Laboratories. A device that provides strictly one-way amplification of signals and is capable of rendering the input impedance independent of the load, and rendering the output impedance independent of the impedance of the signal source which drives it.

2,663,767 Stabilized Crystal Triode System—A. H. Reeves, C. DeBoismaison White. Assignee: International Standard Electric Corporation. The circuit has as one feature a source of short stabilizing pulses, stabilizing means for applying said pulses between the collector and emitter electrodes, and means for supressing the pulses and blocking their application to the base electrode.

2,663,796 Low Input-Impedance Transistor Circuits—G. Raisbeck, R. L. Wallace. Assignee: Bell Telephone Laboratories. Signal-Translating apparatus having a three terminal transistor characterized by a collector output current which is a replica of, and in phase with, its input emitter current; a three terminal autotransformer, and a source having terminals connected to the base of the transistor and to the load.

2,663,800 Frequency Controlled Oscillator System—G. B. Herzog. Assignee: Radio Corporation of America. A system consisting of an oscillator, a frequency determining capacitor, a charging and discharging circuit for the capacitor, an impedance element in said circuit, and a three terminal semiconductor device.

2,663,806 Semiconductor Signal Translating Device—S. Darlington. Assignee: Bell Telephone Laboratories. In a semiconductive device a single zone of one conductivity-type, a pair of spaced zones of the opposite conductivity-type contiguous with the first zone, and a pair of zones of the first type contiguous with the pair of zones of the second type, the device having a U shaped n-p-n-p-n construction.

2,663,829 Semiconductor Translator—W. H. Brattain. Assignee: Bell Telephone Laboratories. The method of forming the collector connection of an n-Type germanium translator that comprises applying a positive bias and a signal voltage between the base and the emitter, applying a variable negative bias between collector and base, and removing said voltages when improvement in amplification results.

2,663,830 Semiconductor Signal Translating Device—B. M. Oliver. Assignee: Bell Telephone Laboratories. A signal translating device comprising a plurality of junction transistors having a common collector and individual base and emitter regions.

2,663,831 Selenium Dry-Disk Rectifier—O. J. Klein. Assignee: International Standard Electric Corporation. The selenium layer of the rectifier contains a halogen and aluminum oxide.

January 5, 1954

2,665,334 Dry Plate Type Rectifier—M. W. Brainard. Assignee. O'Keefe and Merritt Company (one-half interest). A selenium rectifier including two disk shaped members spaced apart in opposed relation and means for mechanically connecting, electrically insulating and sealing the members at their peripheries.

2,665,395 Measuring Circuit—A. E. Feinberg. Assignee: None. A circuit which contains a device responsive to a predetermined value of voltage across a welding gap, and to provide means which will render such device inoperative in the event that the gap voltage increases beyond a predetermined value.

2,665,398 Dry Plate Type Rectifier—M. W. Brainard. Assignee: O'Keefe and Merritt Company (one-half interest). A rectifier adapted to be carried by a shaft including a continuous base plate and a segmental base plate having a plurality of spaced sections, a rectifying element of each of these sections, spaced rectifying elements on the continuous plate, and electrical connecting means.

2,665,399 Rectifier Assembly—F. J. Lingel. Assignee: General Electric Co. A rectifier assembly comprising a pair of enclosed germanium rectifier units each including opposed conducting walls forming terminals of the unit.

January 12, 1954

2,666,139 Semiconductor Relaxation Oscillator—R. O. Endres. Assignee: Radio Corporation of America. A relaxation oscillator comprising a three-terminal transistor, a resistor between a source and the collector, a parallel resonant circuit between the source and the base electrode, means for applying a forward bias potential between the emitter and the base.

2,666,150 Crystal Tetrode—R. T. Blakely. Assignee: International Business Machines Corporation. A device having a base electrode; a plurality of input electrodes of the whisker type, an output electrode of the whisker type, a circuit connection between the base and the output that is responsive to a predetermined output voltage swing, said voltage swing being imposed upon a critical direct voltage.

January 19, 1954

2,666,812 Telephone Signaling System—R. J. Kircher. Assignee: Bell Telephone Laboratories. A station signaling system comprising a central office and a station to be signaled, a semiconductor oscillator at said station whose frequency of oscillation is independent of the frequency of a source of energy, said semiconductor oscillator which when energized will operate an acoustical transducer.

2,666,814 Semiconductor Translating Device—W. Shockley. Assignee: Bell Telephone Laboratories. A device composed of a body of material of one conductivity type having an integral layer on one face thereof of the opposite conductivity type, said layer being between 0.002 and 0.01 cm. thick.

2,666,816 Semiconductor Amplifier—L. P. Hunter. Assignee: Westinghouse Electric Corporation. An amplifier comprising a semiconductor diode, means for applying a direct bias to said diode, means for applying an A.C. signal to said diode of frequency such that a half period is short compared to the life of an anomalous current carrier.

2,666,817 Transistor Amplifier and Power Supply Therefor—G. Raisbeck, R. L. Wallace. Assignee: Bell Telephone Laboratories. An amplifier consisting of a three-terminal transistor, two inductance coils, a steady bias current source connected to the coils, and means for holding constant the total current of the source and supplying desired fractions of the bias current to the emitter and the collector.

2,666,818 Transistor Amplifier—W. Shockley. Assignee: Bell Telephone Laboratories. A device comprising a pair of transistors of opposite conductivity types, a biasing source connected between the two emitters, an input circuit between the base and emitter of one transistor, and an output circuit between the emitter and collector of the same device.

2,666,819 Balanced Amplifier Employing Transistors of Complementary Characteristics—G. Raisbeck. Assignee: Bell Telephone Laboratories. Apparatus which comprises a pair of three-terminal transistors, the voltage current characteristics of which are similar in shape but opposite in sign.

2,666,861 Transducer—R. D. Campbell. Assignee: Reed Research Inc. A transducer for translating quantitative values into pulses and having a semiconductive high-resistivity p-type germanium body whose voltage current characteristic includes a closed loop.

2,666,873 High Current Gain Semiconductor Device—B. N. Slade. Assignee: Radio Corporation of America. A device which has been treated by passing a short, intense pulse of current in the reverse direction between the collector and base electrodes under a condition of steady reverse current flow between said electrodes, and a forward current between the emitter and base electrodes, said treatment producing a device with negligible internal feedback.

2,666,874 Construction of Semiconductor Devices—L. E. Barton. Assignee: Radio Corporation of America. A spherically-shaped semiconducting body whose diameter does not exceed 10 mils is in contact with a low-resistance soft-metal element and a block of insulating material in which are imbedded a pair of wires which make rectifying contact with the semiconductor.

2,666,902 Frequency Modulator Transistor Circuits—L. L. Koros. Assignee: Radio Corporation of America. A means for varying the frequency of a tuned circuit comprising a three-terminal semiconductor device and means for applying operating potentials to the electrodes of said device.

January 26, 1954

2,666,977 Reversible Semiconductor and Method of Making It—W. G. Pfann. Assignee: Bell Telephone Laboratories. The method of making a reversible semiconductor amplifier having two spaced restricted area connections and a large area base connection, that comprises electrically forming the restricted areas as collector connections.

[CONTINUED IN APRIL ISSUE]

CHARACTERISTICS CHARTS of NEW DIODES and RECTIFIERS

ANNOUNCED BETWEEN SEPT. 15, 1958 and NOV. 30, 1958 ONLY

(Continued from February 1959 issue. See Feb. issue for complete list of manufacturers and codes)

SILICON ZENER or AVALANCHE DIODES

TYPE NO.	Zener or Avalanche Voltage Range MIN. E_{b1} (volts)	MAX. E_{b2} (volts)	@ I_z (ma)	Dynamic Impedance Z @ I_z (ohms)	(ma)	MAX. DISS. (mw)	TEMP. CO-EF-FICIENT %/°C	MFR. (See code at start of chart)
1N708	5.1	6.2	25	3.6	25	250	.025	HSD
1N709	5.6	6.8	25	4.1	25	250	.036	HSD
1N710	6.1	7.5	25	4.7	25	250	.041	HSD
1N711	6.7	8.3	25	5.3	25	250	.047	HSD
1N712	7.4	9.0	25	6.0	25	250	.052	HSD
1N713	8.2	10.0	12	7.0	12	250	.057	HSD
1N714	9.0	11.0	12	8.0	12	250	.061	HSD
1N715	9.9	12.1	12	9.0	12	250	.063	HSD
1N716	10.8	13.2	12	10	12	250	.065	HSD
1N717	11.7	14.3	12	11	12	250	.068	HSD
1N718	13.5	16.5	12	13	12	250	.071	HSD
1N719	14.4	17.6	12	15	12	250	.074	HSD
1N720	16.2	19.8	12	17	12	250	.077	HSD
1N721	18.0	22.0	4.0	20	4.0	250	.080	HSD
1N722	19.8	24.2	4.0	24	4.0	250	.082	HSD
1N723	21.6	26.4	4.0	28	4.0	250	.084	HSD
1N724	24.3	29.7	4.0	35	4.0	250	.086	HSD
1N725	27.0	33.0	4.0	42	4.0	250	.088	HSD
1N726	29.7	36.3	4.0	50	4.0	250	.089	HSD
1N727	32.4	39.6	4.0	60	4.0	250	.090	HSD
1N728	35.1	43.9	4.0	70	4.0	250	.091	HSD
1N729	38.7	46.3	4.0	84	4.0	250	.092	HSD
1N730	42.3	51.7	4.0	98	4.0	250	.093	HSD
1N731	45.9	56.1	4.0	115	4.0	250	.093	HSD
1N732	50.4	61.6	4.0	140	4.0	250	.094	HSD
1N733	55.8	68.2	2.0	170	2.0	250	.094	HSD
1N734	61.2	74.8	2.0	200	2.0	250	.095	HSD
1N735	67.5	82.5	2.0	240	2.0	250	.096	HSD
1N736	73.8	90.2	2.0	280	2.0	250	.096	HSD
1N737	81.9	100	1.0	340	1.0	250	.097	HSD
1N738	90.0	110	1.0	400	1.0	250	.097	HSD
1N739	99.0	121	1.0	490	1.0	250	.097	HSD
1N740	108	132	1.0	570	1.0	250	.097	HSD
1N741	117	143	1.0	650	1.0	250	.097	HSD
1N742	135	165	1.0	860	1.0	250	.098	HSD
1N743	144	176	1.0	970	1.0	250	.098	HSD
1N744	162	198	1.0	1200	1.0	250	.098	HSD
1N745	180	220	1.0	1400	1.0	250	.098	HSD
1N1765	5.1	6.2	100	1.2	100	1000	.025	HSD
1N1766	5.6	6.8	100	1.5	100	1000	.036	HSD
1N1767	6.1	7.5	100	1.7	100	1000	.041	HSD
1N1768	6.7	8.3	100	2.1	100	1000	.047	HSD
1N1769	7.4	9.0	100	2.4	100	1000	.052	HSD
1N1770	8.2	10.0	50	3.0	50	1000	.057	HSD
1N1771	9.0	11.0	50	3.5	50	1000	.061	HSD
1N1772	9.9	12.1	50	4.2	50	1000	.063	HSD
1N1773	10.8	13.2	50	5.0	50	1000	.065	HSD
1N1774	11.7	14.3	50	5.8	50	1000	.068	HSD
1N1775	13.5	16.5	50	7.6	50	1000	.071	HSD
1N1776	14.4	17.6	50	8.6	50	1000	.074	HSD
1N1777	16.2	19.8	50	11	50	1000	.077	HSD
1N1778	18.0	22.0	15	13	15	1000	.080	HSD
1N1779	19.8	24.2	15	16	15	1000	.082	HSD
1N1780	21.6	26.4	15	18	15	1000	.084	HSD
1N1781	24.3	29.7	15	23	15	1000	.086	HSD
1N1782	27.0	33.0	15	28	15	1000	.088	HSD
1N1783	29.7	36.3	15	33	15	1000	.089	HSD
1N1784	32.4	39.6	15	39	15	1000	.090	HSD
1N1785	35.1	43.9	15	45	15	1000	.091	HSD
1N1786	38.7	46.3	15	54	15	1000	.092	HSD
1N1787	42.3	51.7	15	64	15	1000	.093	HSD
1N1788	45.9	56.1	15	74	15	1000	.099	HSD
1N1789	50.4	61.6	15	88	15	1000	.094	HSD
1N1790	55.8	68.2	5.0	105	5.0	1000	.094	HSD
1N1791	61.2	74.2	5.0	125	5.0	1000	.095	HSD
1N1792	67.5	82.5	5.0	150	5.0	1000	.096	HSD
1N1793	73.8	90.2	5.0	175	5.0	1000	.096	HSD
1N1794	81.9	100	5.0	220	5.0	1000	.097	HSD
1N1795	90.0	110	5.0	260	5.0	1000	.097	HSD
1N1796	99.0	121	5.0	320	5.0	1000	.097	HSD

SILICON ZENER or AVALANCHE DIODES

TYPE NO.	Zener or Avalanche Voltage Range MIN. Eb1 (volts)	MAX. Eb2 (volts)	@ Iz (ma)	Dynamic Impedance Z (ohms)	@ Iz (ma)	MAX. DISS. (mw)	TEMP. CO-EF-FICIENT %/°C	MFR. (See code at start of chart)
1N1797	108	132	5.0	390	5.0	1000	.097	HSD
1N1798	117	143	5.0	450	5.0	1000	.097	HSD
1N1799	135	165	5.0	600	5.0	1000	.098	HSD
1N1800	144	176	5.0	700	5.0	1000	.098	HSD
1N1801	162	198	5.0	900	5.0	1000	.098	HSD
1N1802	180	220	5.0	1100	5.0	1000	.098	HSD
1N1803	5.1	6.2	1000	1.0	1000	10W	.025	HSD
1N1804	5.6	6.8	1000	1.0	1000	10W	.036	HSD
1N1805	6.1	7.5	1000	1.0	1000	10W	.041	HSD
1N1806	6.7	8.3	1000	1.0	1000	10W	.047	HSD
1N1807	7.4	9.0	1000	1.0	1000	10W	.052	HSD
1N1808	8.2	10.0	500	1.0	500	10W	.057	HSD
1N1809	99.0	121	50	47	50	10W	.097	HSD
1N1810	108	132	50	56	50	10W	.097	HSD
1N1811	117	143	50	65	50	10W	.097	HSD
1N1812	135	165	50	82	50	10W	.098	HSD
1N1813	144	176	50	93	50	10W	.098	HSD
1N1814	162	198	50	115	50	10W	.098	HSD
1N1815	180	220	50	140	50	10W	.098	HSD
R3.9	3.6	4.3		20	40	1000	.04	GIC
R4.7	4.3	5.1		10	40	1000	.00	GIC
R5.6	5.1	6.2		4.5	40	1000	.03	GIC
R6.8	6.2	7.5		6.5	20	1000	.05	GIC
R8.2	7.5	9.1		9.0	20	1000	.06	GIC
R10	9.1	11.0		12	20	1000	.07	GIC
R12	11.0	13.0		25	10	1000	.075	GIC
R15	12.0	16.0		50	10	1000	.08	GIC
R18	16.0	20.0		70	10	1000	.085	GIC
R22	20.0	24.0		120	10	1000	.09	GIC
R27	24.0	27.0		200	10	1000	.095	GIC
SX47	4.45	4.95	5.0	11	20	300	.04	GECB
SX51	4.95	5.30	5.0	10	20	300	.03	GECB
SX62	5.9	6.5	5.0	4.0	20	300	.01	GECB

SWITCHING DIODES

TYPE NO.	MAT	PIV (volts)	MAX. CONT. REV. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f (mA)	@ E_f (volts)	Reverse Impedance @ 25°C Z (K ohms)	Voltage Range E_{b1} to (volts)	E_{b2} (volts)	Recovery Characteristics Test Conditions Fwd. I_f (ma)	Rev. to E_b (volts)	$Z_{rec.}$ (K ohms)	@ time (t) (usec)	MFR. (See code at start of charts)
1N770	Ge		20	15	.50	250	10		5.0	10	15	.35	CBS
1N778	Si		100	10	1.0		100		5.0	40	400	.30	CTP
1N779	Si		175	10	1.0		175		5.0	40	400	.30	CTP
CTP2310	Si		130	5.0	1.5		125		5.0	40	400	1.0	CTP
CTP2312	Si		70	5.0	1.5		60		5.0	40	400	.30	CTP
CTP2314	Si		180	5.0	1.5		175		5.0	40	400	.30	CTP
CTP2316	Si		70	5.0	1.5		60		5.0	40	400	1.0	CTP
CTP2325	Si		180	30	1.5		175		20	40	80	.50	CTP
CTP2359	Si		36	100	1.5		30		20	40	80	.50	CTP
CTP2375	Si		70	30	1.5		60		20	40	80	.50	CTP
EW781	Si	60	60	10	1.0	6000	10	60	10	30	600	.20	GECB
EW782	Si	120	120	10	1.0	12M	10	120	10	30	1200	.20	GECB
PS700	Si	30		100	1.0						100	1.0	PSI
PS701	Si	60		50	1.0						100	.50	PSI
PS702	Si	100		75	1.0						100	1.0	PSI
PS703	Si	100		50	1.0						100	.50	PSI
PS704	Si	150		50	1.0						100	.50	PSI
PS705	Si	200		50	1.0						100	.50	PSI

VOLTAGE VARIABLE CAPACITOR DIODES

TYPE NO.	CAPACITANCE C @ Eb		PIV	Q @ FREQ.		MFR.
	(uuf)	(volts)		Min. Q	(mc)	
6.8SC20	6.8	10	200	1000	1.0	INRC
EW76	4.0	10	30	$.8\text{-}Q/Q_o$	50	GECB
HC7001	35	4.0	130	360	5.0	HUG
HC7002	50	4.0	80	330	5.0	HUG
HC7004	70	4.0	60	270	5.0	HUG
HC7005	100	4.0	25	200	5.0	HUG
HC7006	35	4.0	25	175	5.0	HUG
HC7007	50	4.0	25	175	5.0	HUG
HC7008	70	4.0	25	175	5.0	HUG
MA460A	8.0 max.	0		2.0	10000	MIC
MA460B	6.0 max.	0		3.0	10000	MIC
MA460C	4.0 max.	0		4.0	10000	MIC
MA460D	4.0 max.	0		5.0	10000	MIC
MA460E	3.0 max.	0		6.0	10000	MIC

MISCELLANEOUS DIODE TYPES

TYPE NO.	CLASSIFI-CATION	DESCRIPTION	MFR.
1N53B	1,2	35kmc.(Ka band) Mixer diode.	MIC
1N53BM	1,2	Matched pair of 1N53B.	MIC
1N78B	1,2	Ku band mixer diode.	MIC
1N78BM	1,2	Matched pair of 1N78B.	MIC
GEM1	2	X band (12kmc. max.) Germanium mixer diode.	GECB
GEM2	2	Reversed polarity GEM1.	GECB
S180	Silicon Avalanche Switch Diode:	Breakdown Voltage - 6 to 7.5V. at 1ma. Switching time - .15musec. Max. diss. - 250 mw.	SSD
SX640	Variable Resistance Silicon Diode -	The voltage across the device is proportional to the logarithm of the current through it over five decades.	GECB

THE FOLLOWING MANUFACTURERS HAVE ANNOUNCED THAT THEY HAVE BEGUN SUPPLYING THE INDICATED PREVIOUSLY REGISTERED DIODES AND RECTIFIERS

BRADLEY: 1N536, 1N537, 1N538, 1N540, 1N607, 1N608, 1N609, 1N610, 1N611, 1N612
CBS-HYTRON: 1N68A, 1N95, 1N96, 1N97, 1N98, 1N99, 1N100, 1N107, 1N108, 1N117, 1N118, 1N273, 1N276, 1N277, 1N278, 1N279, 1N281, 1N283, 1N287, 1N288, 1N289, 1N291, 1N292, 1N298, 1N447, 1N448, 1N449, 1N450, 1N452, 1N453, 1N454, 1N631, 1N632, 1N633, 1N634
CLEVITE: 1N625, 1N626, 1N627, 1N628, 1N643, 1N658, 1N659, 1N660, 1N661, 1N662, 1N663
COLUMBUS Electronics Corp.: 1N536, 1N537, 1N538, 1N539, 1N540
ERIE Resistor Corp.: 1N34A, 1N38A, 1N48, 1N55, 1N67A, 1N90, 1N96, 1N116, 1N126A, 1N191, 1N192
GENERAL Instrument Corp.: 1N645, 1N646, 1N647, 1N648, 1N649, 1N1119, 1N1120, 1N1487, 1N1488, 1N1489, 1N1490, 1N1491, 1N1492, 1N1692, 1N1693, 1N1694, 1N1695
PACIFIC Semiconductor, Inc.: 1N659, 1N660, 1N661
RAYTHEON: 1N1763, 1N1764
SEMI-ELEMENTS, Inc.: 1N34, 1N34A, 1N38, 1N38A, 1N38B, 1N39, 1N39A, 1N43, 1N44, 1N45, 1N46, 1N47, 1N48, 1N51, 1N52, 1N54, 1N54A, 1N55, 1N55A, 1N55B, 1N56, 1N56A, 1N57, 1N58, 1N58A, 1N60, 1N61, 1N63, 1N64, 1N66, 1N67, 1N67A, 1N68, 1N68A, 1N69, 1N69A, 1N70, 1N70A, 1N72, 1N73, 1N74, 1N75, 1N81, 1N81A, 1N82, 1N82A, 1N86, 1N88, 1N90, 1N95, 1N97, 1N99, 1N111, 1N112, 1N113, 1N114, 1N115, 1N116, 1N116A, 1N117, 1N119, 1N120, 1N126, 1N126A, 1N127, 1N128, 1N142, 1N191, 1N192, 1N194, 1N194A, 1N195, 1N196, 1N198, 1N198A, 1N268, 1N294, 1N295, 1N297, 1N314, 1N355, 1N476, 1N477, 1N478, 1N479, 1N541, 1N616, 1N617, 1N618, 1N625, 1N626, 1N627, 1N632, 1N636
SYLVANIA: 1N126A, 1N127A, 1N128, 1N198, 1N270, 1N276, 1N279, 1N 283, 1N295, 1N297, 1N298, 1N695

HIGH VOLTAGE SILICON RECTIFIERS

	Peak Inverse Voltage	Maximum Average Rectified Current(ma)		Maximum Surge Current Amps	Forward Voltage at Specified Current at 25° C	Inverse Current at Rated Voltage	
		50° C	150° C			25° C(μa)	125° C(μa)
1N560	800	500	250	5	1.3v at 250ma	10	300
1N561	1000	500	250	5	1.3v at 250ma	10	300
1N588	1500	25	10		10v at 10ma	5	100
1N589	1500	50	25		5v at 50ma	5	100

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SEMICONDUCTOR & SOLID-STATE BIBLIOGRAPHY

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Zeeman Splitting of Donor States in Germanium	Canadian Journal of Physics 9/58	The linear Zeeman effect of the 2 $pm = +1$ donor states is calculated in the effective mass approximation.	R. R. Haering
On the Application of Zener Diodes to Expanded Scale Instruments.	Communications and Electronics 9/58 (AIEE)	Results show that limited-range high-accuracy measurements can be achieved. Applications include *a-c* V/I and frequency measurements.	A. J. Corson
Transistor-Oscillator Induction-Motor Drive	Communications and Electronics 9/58 (AIEE)	Transistors and saturable-core-transformer oscillators driving small 2-phase induction motors provide, in effect, a d-c motor without a commutator.	W. H. Card
Current-Balancing Reactors for Semiconductor Rectifiers	Communications and Electronics 9/58 (AIEE)	Discussion of anode-balancing reactors, semiconductor rectifiers, reactor systems, design of reactors, and test results.	I. K. Dortort
Wide Range Transistor Multivibrator	Electronic Design 9/3/58	Periods up to 250 *msec* are possible with longer periods obtained by varying component value within reason.	T. P. Sylvan
Designed Curves for Stabilizing Transistors with Thermistors	Electronic Design 9/17/58	Series of curves permit derivation of thermistor values to counteract variation in saturation current (I_{co})	T. R. Nisbet
Power Dissipation in Class B Circuitry	Electronic Design 9/17/58	Analysis, in detail, of transistor dissipation in Class B Operation.	C. F. Wheatly
A Simple Transistor Amplifier for Energizing a Hall Multiplier	Electronic Engineering (Brit) 9/58	The amplifier described has a current source with high impedance to provide true multiplication between current in the plate and flux density.	D. J. Lloyd
Designing Transistor Circuits-Combinational Circuits, Part 1	Electronic Equipment Engineering 9/58	Types of logic representation applicable to combinational circuits are outlined. Discussion of "level" type of representation.	R. B. Hurley
Capacity Neutralization of *H-F* Transistors	Electronic Industries 9/58	The small-signal, short-circuit, reverse-transfer admittance parameter of *i-f* transistor amplifiers must be neutralized. The capacity needed is derived.	L. S. Greenberg R. C. Wonson
Transistorized Vehicle Speedmeter	Electronic & Radio Engineer (Brit) 9/58	Electronic pulse-counting techniques are applied to measure the time taken for a vehicle to traverse a short known distance.	D. R. Ollington
Transistors Ruggedize Airborne Telemetry Key	Electronics 9/12/58	Transistor pulse-duration-modulation keyer provides high linearity, low crosstalk and jitter, and high effective input impedance.	D. A. Williams, Jr.
Solid-State Panel Amplifies X-Rays	Electronics 9/12/58	Principle of operation; high-gain panel design; input-output characteristic; decay properties; control circuits; applications.	B. Kazan
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An Audio Console Designed For the Future	IRE Trans. on Bdcast Trans Sys. 9/58	Description and circuit discussion of unit in which all amplifiers are completely transistorized.	A. C. Angus
Receiver Video Transistor Amplifiers	IRE Trans. on Bdcast and TV Rec. 9/58	The problem of the common emitter video amplifier is divided into three categories according to the relative positions of device and load time constants.	R. G. Salaman
Transistor Circuitry Utilized in a New TV Sync Generator	IRE Trans. on Bdcast and TV Rec. 9/58	This paper is intended primarily to cover many of the transistor circuits which have been found useful in this service.	L. M. Leeds
The Transistor and the Circuit Application Engineer.	IRE Trans. on Bdcast and TV Rec. 9/58	Analogy and parallelism to vacuum tube, bearing in mind physical and operational differences between transistor and vacumm tube.	F. L. Abboud
Transistor Thermal Stability	IRE Trans. on Bdcast and TV Rec. 9/58	The thermal stability of a transistor connected in a general bias circuit, with no signal applied, is analyzed.	M. J. Hellstrom

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Matrix Analysis of Oscillators and Transistor Applications	IRE Trans. on Circuit Theory 9/58	Application of equations to transistors; practical circuits for dual oscillators; bias elements and their effect on frequency and starting conditions.	A. J. Cote, Jr.
Axioms on Transactors	IRE Trans. on Circuit Theory 9/58	Paper sets out to answer: Are there by analogy to the three ideal passive elements *R*, *L*, and *C* a group of ideal active elements?	G. E. Sharpe
A Transistor Pulse Generator For Digital Systems	IRE Trans. on Electronic Computers 9/58	Design procedure for a new transistor pulse generator circuit suitable for use as a building block in a digital system.	D. J. Hamilton
Design of *A-C* Computing Amplifiers Using Transistors	IRE Trans. on Electronic Computers 9/58	Design philosophy is presented. Design procedure for a summing amplifier to drive a specific resolver in a 400 *cps* system is described.	C. A. Krause R. R. Lowe
The Performance of Bismuth Telluride Thermojunctions	Journal of Applied Physics (British) Sept. 1958	The thermoelectric properties of *n*-type and *p*-type bismuth telluride between 150° K and 300° K have been measured and the figure of merit for thermoelectric applications has been calculated.	H. J. Goldsmid A. R. Sheard D. A. Wright
Gain, Band Width, and Noise Characteristics of the Variable-Parameter Amplifier	Jnl. of Applied Physics 9/58	Specifically it is shown that to increase gain, the Q of one of the resonant circuits must be increased or the variation in the variable reactance must be increased.	H. Heffner G. Wade
Diffusion of Indium in Tin Single Crystals	Jnl. of Applied Physics 9/58	The rate of diffusion of indium in single crystals for two orientations has been measured using radioactive isotope In^{114}	A. Sawatzky
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The Reaction of Germanium with Nitric Acid Solutions. I – The Dissolution Reaction	Jl. of the Electrochemical Society 9/58	The rection of single-crystal germanium with HNO_3 was studied as a function of concentration, stirring rate, and temperature.	M. C. Cretella H. C. Gatos
The Reaction of Germanium with Nitric Acid Solutions. II – Passivity of Germanium	Jl. of the Electrochemical Society 9/58	Above 6 to 8*N* HNO_3, the initial dissolution of germanium decreased with increasing HNO_3 concentration and stirring rate.	M. C. Cretella H. C. Gatos
Preparation and Properties of Aluminum Antimonide	Jl. of the Electrochemical Society 9/58	Effects of various impurities in the starting materials and crucibles on the electrical properties are discussed. Crystal growing described.	A. Herczog R. R. Haberecht A. E. Middleton
Photoconductivity in Lead Selenide	Journal of Electronics and Control (Brit) 9/58	Work has been carried out in lead selenide in three forms: chemically deposited films, solid filaments, and evaporated films.	D. H. Roberts
A note on Surface Recombination Velocity and Photoconductive Decays	Journal of Electronics and Control (Brit) 9/58	It is pointed out that the range of validity of the formulae commonly used is not as wide as implied owing to a deficiency in the reasoning behind their derivation.	A. C. Sim
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Hall Effect in Lu, Yb, Tm and Sm	Physical Review Sept. 1, 1958	The Hall effect in these materials has been studied as a function of temperature for the temperature range 40° K to 320° K in a magnetic field of 5500 oe.	G. S. Anderson F. H. Spedding S. Legvold
Fine Structure in the Absorption-Edge Spectrum of Silicon	Physical Review Sept. 1, 1958	Measurements of the absorption spectrum of Si have been made with high resolution at various temperatures between 4.2° K and 415° K.	G. G. Macfarlane J. E. Ouarrington T. P. McLean V. Roberts
Control of Luminescence by Charge Extraction	Physical Review Sept. 1, 1958	It has been discovered that the application of a potential of a few volts to phosfors of the ZnS group can quench the fluorescence.	P. J. Daniel R. F. Schwarz M. E. Lasser L. W. Hershinger
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Optical Properties of *n*-Type InP	Physical Review 9/15/58	Measurements of the intrinsic absorption edge of n-type InP at 77° K and 300° K are reported. Differences are found in the spectra of samples of differing origin.	R. Newman
Recombination Properties of Gold In Silicon	Physical Review Sept. 15, 1958	The presence of gold atoms in the silicon lattice decrease the lifetime of excess electrons and holes in *p*- and *n*-type material.	G. Bermski
Quenching, Stimulation, and Exhaustion Studies on Some Infrared Stimulable Phosfors	Physical Review Sept. 15, 1958	Two stimulation bands have been measured and the relative efficiencies of exhaustion and of stimulation of visible emissions by the two bands have been studied.	S. P. Keller G. D. Pettit
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A Transistorized All Electronic Low-Level Pulse Width Multicoder	Proceedings Nat'l Symposium on Telemetering, 1958	A means of multiplexing voltages on the order of 30 *mv* full scale and an associated system for conversion to a pulse width modulated output.	J. A. Riedel, Jr.
Pulse Code Modulation of Commutated Subcarrier Signals	Proceedings Nat'l Symposium on Telemetering, 1958	Description of system and transistorized airborne and ground based equipment.	T. D. Norzecha
Transistorized "S" Band Beacon System	Proceedings Nat'l Symposium on Telemetering, 1958	A silicon transistor beacon system has been designed which incorporates a receiver, decoder, and transmitter.	E. Y. Politi
A Transistor Telemetering System for Conservation Research	Proceedings Nat'l Symposium on Telemetering, 1958	A transistorized radio telemeter is described. Features which make the system suitable for conservation research data collection are discussed.	J. Althouse B. S. Skinner
A Transistorized Calibrator for Missile Telemetry	Proceedings Nat'l Symposium on Telemetering, 1958	This paper describes a transistorized in-flight calibrator for use with the Jupiter missile.	O. B. King
Completely Transistorized Current/Voltage Controlled Oscillator	Proceedings Nat'l Symposium on Telemetering, 1958	Theory, construction and operation of a system which reliably converts a-c/d-c input currents/voltages from transducers to FM signals.	W. H. Foster
Analysis and Performance Characteristics of Transistorized Subcarrier Oscillator Circuits for Airborne Telemetering	Proceedings Nat'l Symposium on Telemetering, 1958	Evaluation of various transistor circuits including a special purpose subcarrier oscillator using the unijunction transistor.	E. M. Wilkinson
A Transistorized Analog Signal Converter for Missile Telemetry	Proceedings Nat'l Symposium on Telemetering, 1958	Electrical and mechanical design of a transistorized Analog Signal Converter for use with the guidance system of Titan is described.	R. P. Kittel
A Transistorized Voltage Controlled FM Subcarrier Oscillator	Proceedings Nat'l Symposium on Telemetering, 1958	A voltage-sensing, FM subcarrier oscillator has been developed to permit a telemetering system to operate reliably with minimum power under severe environmental conditions.	A. M. Chwastyk
A Transistor-Driven Magnetic-Core Memory Using Non-Coincident Current Techniques	Proceedings Nat'l Symposium on Telemetering, 1958	Drivers utilize silicon transistors for high temperature operation. These transistors are operated normally cut off.	R. L. Koppel
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A High Level Magnetic Core Commutator	Proceedings Nat'l Symposium on Telemetering, 1958	Paper discusses magnetic core theory, ring counter operation, switching circuit, driver circuit, trigger and synchronization and applications of semiconductor devices.	J. B. Crank M. E. North

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A Pulse Position Telemetry System	Proceedings Nat'l Symposium on Telemetering, 1958	For purposes of miniaturization the demodulation channels have been transistorized with grown junction and alloy junction silicon types.	L. Weisman E. Teltscher
Satellite Environment Via One-Milliwatt Oscillators	Proceedings Nat'l Symposium on Telemetering, 1958	Discussion of circuit-design philosophy and practical circuits using transistors and fractions of a milliwatt per measurement.	J. M. Riddle
Design Considerations for Direct-Coupled Transistor Amplifiers	RCA Review Sept. 1958	Procedure described is to seek a relationship between the driving source and the amplifier which will yield optimum performance with respect to signal-to-drift ratio.	J. E. Lindsey H. J. Woll
Effect of Crystal Growth Variables on Electrical and Structural Properties of Germanium	RCA Review Sept. 1958	Examination of dislocation etch-pit distribution revealed plastic deformation by octahedral slip in germanium crystals grown by the Czochralski technique.	F. D. Rossi
Metallographic Aspects of Alloy Junctions	RCA Review Sept. 1958	Defects in the junction structure of large area alloy junction transistors have been found to be associated with the presence of oxide films on the indium and germanium surfaces.	A. S. Rose
Lattice Defects in Germanium and Silicon and the Effect on Electrical Properties	U.S. Govt. Res. Reports PB127143-LC 9/12/58	The barrier height was determined by observing the saturation of the open circuit junction decay voltage with increasing forward bias.	P. L. Copeland J. R. Madigan L. J. Fiegee
Investigations of Surface Properties of Silicon and other Semiconductors	U.S. Govt. Res. Reports PB127211-LC 9/12/58	The diffraction tubes for germanium and silicon crystals and a tungsten crystal are described. Method of preparing a (100) surface of silicon crystals.	H. E. Farnsworth J. A. Dillon, Jr R. E. Schlier
Design of Push-Pull Single Ended Transistor Amplifiers	U.S. Govt. Res. Reports PB127143-LC 9/12/58	Two such circuits are analyzed, one using a transformer driver, the other a transistor phase-inverter driver.	M. I. Plowsky
Research on Methods of Treating Cadmium Sulfide Elements	U.S. Govt. Res. Reports, PB131847-OTS 9/12/58	This study forms a part of a program for the development of a cadmium sulfide single crystal solar battery.	A. Carlson W. Deshotels J. M. Jost L. R. Shiozawa
Research on Aluminum Antimonide for Semiconductor Devices	U.S. Govt. Res. Reports PB131849-OTS 9/12/58	Development of purification, and crystal growing techniques; feasibility of device operation at 500° C.	A. Herczog R. R. Haberecht A. E. Middleton
Industrial Prepardness Study for Diffused Semiconductor Devices	U.S. Govt. Res. Reports PB127423-LC 9/12/58	Progress in establishing feasibility on germanium pulse transistor core driver, silicon audio transistors, 20W power transistors, and 4.3 *mc* amplifier.	
Circuit Properties of Hook Transistor	U.S. Govt. Res. Reports PB132956-LC 9/12/58	Comparisons with other types include switching speed amplifying properties, various impedances. and the dual case.	L. M. Vallese
Design Considerations for Two Types of Transistorized Multivibrator Circuits	U.S. Govt. Res. Reports PB131538-OTS 9/12/58	Report outlines procedure for selecting the circuit resistors and capacitors for transistor multivibrator circuits.	P. Emile
Research on Semiconductor Films	U.S. Govt. Res. Reports PB132274-LC 9/12/58	Cadmium sulfide films on rigid substrates were prepared by vacuum evaporation techniques and given electrode coatings exhibiting strong voltaic responses.	A. Carlson
Intrinsic-Barrier Transistor Techniques	U.S. Govt. Res. Reports PB127208-LC 9/12/58	First step in the development and establishment of techniques suitable for pilot production of high-quality intrinsic barrier transistors.	J. L. Buie
Junction-Transistor *H-F* Equivalent Circuit	U.S. Govt. Res. Reports PB127226-LC 9/12/58	A new junction transistor equivalent circuit derived from theoretical principles and valid up to and beyond alpha cut-off frequency is presented.	R. D. Middlebrook
Industrial Prepardness Study on Power Transistors	U.S. Govt. Res. Reports PB132572-LC 9/12/58	Development of a pilot line of *a-f* transistors from 1 to 10 watts. Capacity of this pilot line was to be 3,000 starts and 1,650 finished units per day.	E. J. Quirk
Industrial Prepardness Study on Diffused Semiconductor Devices Nos. 19, 23 and 28.	U.S. Govt. Res. Reports PB127412-LC 9/12/58	A method for diffusion of an extremely thin, uniform *p* layer during growth of a silicon crystal is described. Complete fabrication methods of present state-of-the-art transistors are given.	W. C. Brower C. Earhart H. L. Owens W. A. Adcock

✓New Products

Fast Switching Mesa Transistors

Commercial production of the 2N559 ultra high frequency, diffused base "mesa" germanium transistors for highly advanced military and commercial applications was announced recently by Texas Instruments. Switching speeds into the millimicrosecond range and a typical alpha cutoff frequency of 250 megacycles make the TI 2N559 ideally suited for ultra high speed switching applications. It is conservatively rated to dissipate in excess of 150 milliwatts in free air and will operate at temperatures up to 100°C. Available in a miniature round-welded case.

Circle 101 on Reader Service Card

Driver Transistors

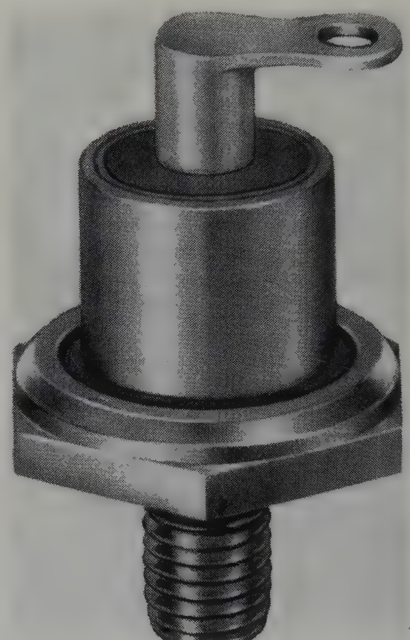
A new germanium driver transistor series that can be used in audio amplifiers, audio oscillators, Class A and Class B amplifiers, power switches, servo controls, relay drivers and motor controls has been announced by Bendix. The versatile transistor, designated 2N1008-A-B and contained in the JEDEC TO-9 package, dissipates 400 milliwatts of power at 25 degrees C. and 67 milliwatts at 75 degrees C. The series has a voltage range from 20 to 60 volts, and a maximum current gain of 150, combined with high linear current gain characteristics to permit switching applications and lower-distortion output.

Circle 102 on Reader Service Card

High Temperature Power Rectifier

A heavy-duty 35-ampere power rectifier, Type 4A, has been added to Fansteel Metallurgical Corporation's growing line of silicon rectifiers. The unit carries a full 35-ampere load in half-wave service and up to 100 amperes in bridge circuits. It is available with peak reverse ratings from 50 to 400 V. in 50-volt multiples, and is applicable to all types of power circuits. Hermetically sealed, can be operated at ambient temperatures up to 165°C and is unaffected by storage temperatures from —65° to 200°C.

Circle 103 on Reader Service Card



New Plastic

Baker Chemical Co. announces the development of a new transparent acrylic-type thermoplastic polymer for injection molding and extrusion which has exceptionally high heat resistance. This new plastic, presently designated as PL-11, is similar in mechanical and optical properties to polymethyl methacrylate, but has a heat distortion temperature of about 250°F, approximately 50°F higher than the heat distortion point of polymethyl methacrylate. It may be immersed indefinitely in boiling water without affecting its water-white transparency.

Circle 106 on Reader Service Card

Silicon Transistor

A new low-level silicon transistor, the ST1026, developed by Transitron Electronic Corp. can greatly reduce drift in D. C. amplifiers. The ST1026 provides excellent gain at very low currents and has particularly low collector leakage at typical operating voltages. Write for Bulletin TE-1353.

Circle 136 on Reader Service Card

Small-Signal Transistor

The 2N1010, newest addition to RCA's line of transistors for af amplifier service, is a germanium alloy-junction transistor of the n-p-n type. It is especially suited for use in the input stages of high-fidelity preamplifiers, tape recorders, microphone preamplifiers, and hearing aids in which low noise factor is an important design consideration. 2N1010 has a noise factor of only 5 db with a generator resistance of 1000 ohms and an integrated noise bandwidth of 15 kilocycles, typical small-signal current gain of 35, alpha-cutoff frequency of 2 megacycles, and freedom from microphonics and hum.

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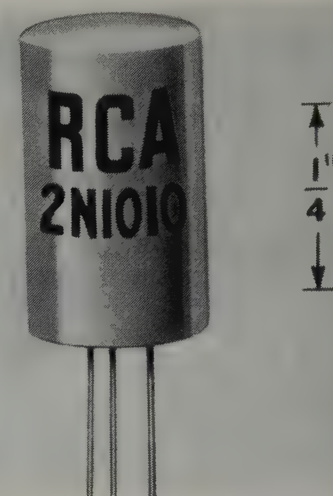


Silicon Solar Cells

To provide accurate radiation measuring standards with which to check the efficiencies of production silicon solar cells, International Rectifier Corp. has announced the availability of Secondary Standard Silicon Solar Cells. These cells are specifically designed for calibration of artificial light sources in terms of solar energy radiation. They may be considered to be the solar cell analog to the pyroheliometer standard. Manufacturers using them can evaluate incoming solar cells for efficiency, without the need of a pyroheliometer or other complex light-measuring device. Request Bulletin SR-277.

Circle 135 on Reader Service Card

Silicon Power Diodes

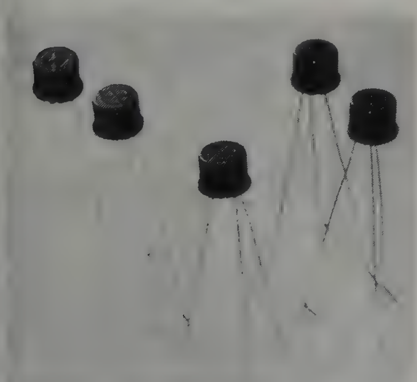
High current silicon power rectifiers providing d.c. forward currents up to 250 amperes with a maximum peak inverse voltage range from 50 to 500 volts are available from International Rectifier. Designed for use at high temperatures; capable of operation at a junction temperature of 190°C. Engineered and manufactured to meet the most rigid military specifications, they utilize the latest techniques in hermetic sealing to provide additional reliability in environmental extremes of temperature, vibration and shock. Request Bulletin SR-305.

Circle 121 on Reader Service Card

High Speed Switching Transistors

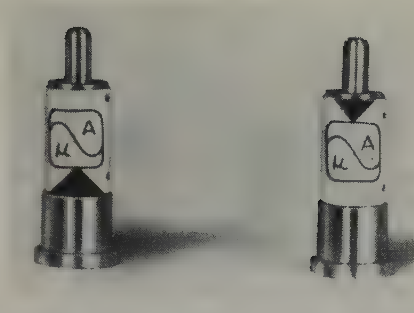
Fairchild 2N1131 and 2N1132 are PNP silicon transistors closely matching Fairchild's 2N696 and 2N697 types. Existence of these closely related devices of opposite polarity affords opportunities for circuit designs based on complementary symmetry. PNP silicon transistors also have special applications by themselves. Typical rise time is 80 milli-micro-seconds. Dissipation ratings are 2 watts at 25°C. and 1 watt at 100°C.

Circle 139 on Reader Service Card



Varactor Diodes

Microwave Associates announces the new silicon varactor, a diffused silicon PN junction diode designed to be a variable capacitance with low loss at high frequencies. The unit complies with MIL-E-1 outline 7-1 for cartridge type crystal rectifiers and will fit most standard crystal holders. In the standard MA-460 series, the pin end of the diode is connected to P-type material on the top of a small "mesa" and the N-side of the silicon element is connected to the base. The reversed polarity unit denoted by the suffix R is also available. The minimum cutoff frequencies are graded in 10 kMc steps



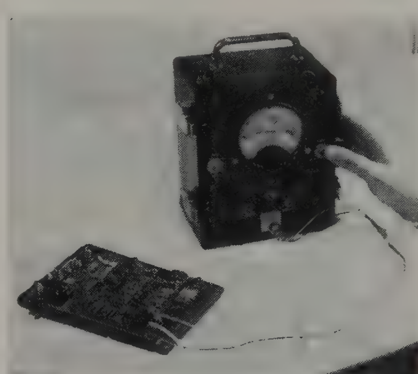
starting with the suffix A at 20 kMc. Units are currently available as high as 60 kMc. Request Bulletin 59V.

Circle 116 on Reader Service Card

In-Circuit Transistor Tester

A transistor tester capable of checking the performance of transistors while they are connected within their circuits, will be available from Philco in the near future. In-circuit transistor testing is extremely important since the method saves trouble shooting and servicing time without turning on power in the equipment. Low impedance methods are employed in both the input and output circuits to nullify the effects of the external circuitry.

Circle 125 on Reader Service Card



Silicon Bridge Rectifiers

Miniature silicon bridge rectifiers for replacement of bulky vacuum tube units occupy 1/10 of the volume and weigh less than 1/60 of equivalent tube circuitry. Announced by International Rectifier Corp., units measure 1.22 x 1.03 x .750 inches and weigh ½ oz. Designed primarily to provide extreme miniaturization in missile, airborne and ground system circuitry, these rugged, shock-

resistant devices may be operated at temperatures up to 165°C. Available with ratings from 50 to 600 PIV, with dc output currents ranging from 50 ma to 1.2 amperes. Request Bulletin SR-207.

Circle 142 on Reader Service Card

Subminiature Crystal Diodes

All-glass, subminiature crystal diodes for use in radio, hi-fi, television, data processing, and other military and commercial electronic applications have been announced by Sylvania. Simplifies mechanical layouts and makes possible more compact circuit designs. Maximum body length .265 inches; maximum diameter .105 inches. Includes computer types, gold bonded types, point contact types, and silicon junction types.

Circle 130 on Reader Service Card

High Voltage Rectifiers

Raytheon announces 12 new High Voltage Silicon Rectifiers made by the diffused junction process. Working voltage ratings range from 800 to 2,000 volts and all types have a maximum drop of 2 volts at the rated working voltage. Types 1N2120 through 1N2125 are in the 0.28" diameter case with wire-in construction. Types 1N2140 through 1N2145 are in the small stud package having a 10-32nd thread and 7/16" hex nut.

Circle 140 on Reader Service Card

High-Speed Switching Transistors

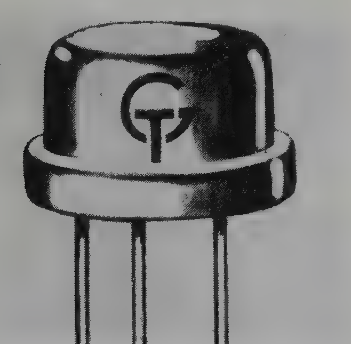
Sprague announces Type 2N501 Germanium Super High-Speed Switching Transistor, a micro alloy diffused-base transistor designed for high-speed computer applications with ultra-low rise, storage, and fall times. Because of the electrochemical process, Sprague is able to fabricate a graded-base transistor with no intrinsic base region which can thus maintain its high-speed switching characteristics right down to its saturation voltage, providing all the advantages of direct-coupled circuitry with no impairment of switching speeds.

Circle 105 on Reader Service Card

New Silicon Unit

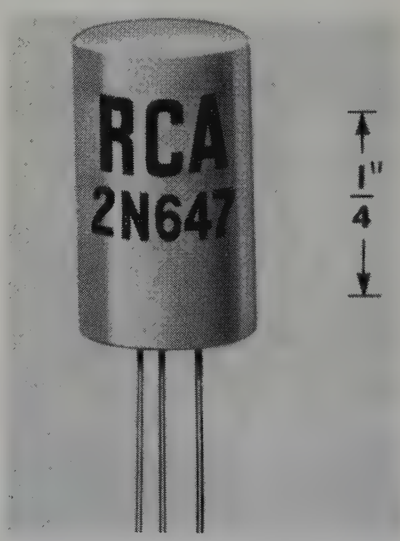
General Transistor has announced a high speed, high gain, silicon PNP alloy junction transistor to meet industrial and military needs for devices of this type. The unit will be commercially available in quantity by the spring of 1959. Development of the unit has significance beyond its use in DC amplifiers and other linear applications, since it will make the use of silicon possible in such further applications as direct coupled and resistance coupled transistors and other extensions of transistor logic.

Circle 111 on Reader Service Card



Junction Transistor

The RCA 2N647 is a new alloy-junction transistor of the germanium n-p-n type intended especially for use along with its p-n-p counterpart, RCA-2N217, in class B Complementary-Symmetry power output stages of transformerless, battery-operated portable radio receivers, phonographs, and audio amplifiers. It is par-

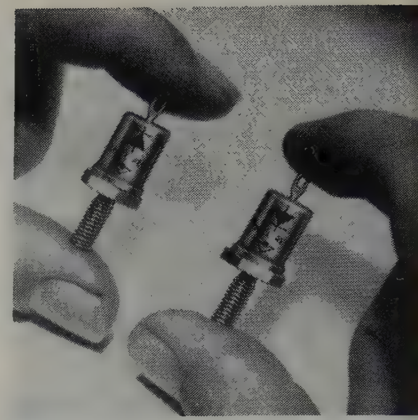


ticularly useful in equipment in which compactness, good frequency response, and relatively high power output are important design considerations. May also be used in conventional class B push-pull and in class A audio-amplifier circuits.

Circle 120 on Reader Service Card

High Voltage Silicon Rectifiers

1500 PIV, 300 ma rated silicon rectifiers are now available from International Rectifier. These extremely stable units offer reverse leakages as low as 100 μa at 75°C (at rated PIV of −1500 volts dc). Maximum forward voltage drop at a test temperature of 25°C at 150 ma is 4.5 volts. Designed primarily for high temperature



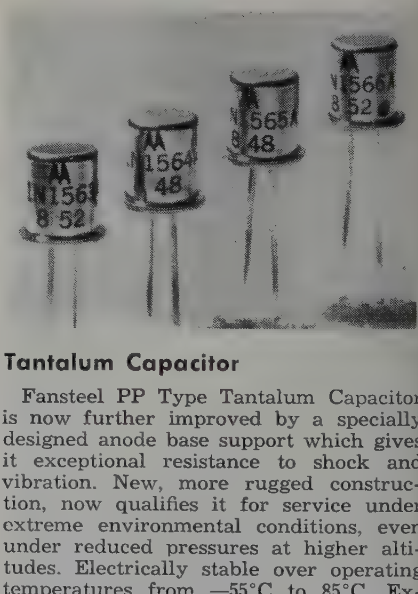
operation, these units are stud mounted for optimum heat dissipation, and may be operated at temperatures up to 150°C. Request Bulletin SR-226.

Circle 122 on Reader Service Card

Silicon Rectifiers

A new series of silicon rectifiers for military and industrial applications has been announced by the semiconductor products division of Motorola. Types 1N1563A through 1N1566A offer peak inverse voltages of 100 through 400. One cycle average reverse current is limited to 150 μa maximum when rectified output is 250 ma and ambient temperature is 150°C. Forward rectified currents are 1.5 amps and 250 ma at 25°C and 150°C ambient temperatures.

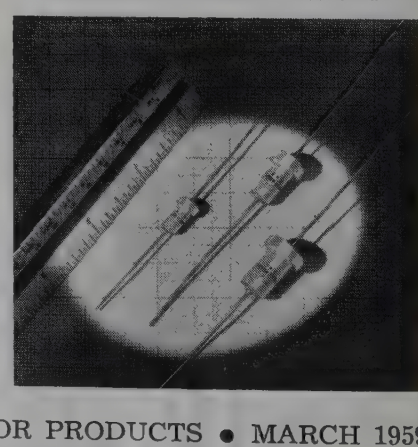
Circle 123 on Reader Service Card



Tantalum Capacitor

Fansteel PP Type Tantalum Capacitor is now further improved by a specially designed anode base support which gives it exceptional resistance to shock and vibration. New, more rugged construction, now qualifies it for service under extreme environmental conditions, even under reduced pressures at higher altitudes. Electrically stable over operating temperatures from —55°C to 85°C. Exhibits outstanding frequency stability and negligible electrical leakage.

Circle 148 on Reader Service Card



Micro-Miniature Battery

A new mercury battery has been developed by the Mallory Battery Company, a division of P. R. Mallory & Co. Only 0.300 inches in diameter and 0.125 inches high, it is designed to fit the dimension requirements of the military micro-module program. Its indicated uses include extremely small hearing aids, portable radiation detectors, and other miniaturized electronic devices. The new cell is designated the RM-312. Its energy life is approximately 36 milliampere hours at a discharge of 2 milliamperes at 1.22 average volts.

Circle 117 on Reader Service Card

Transistor Power Supply

A new transistor power supply offered by Mid-Eastern Electronics, features stable output voltages from 0 to 36 V d.c. at 5 amps continuous duty. Line and load regulation is better than 0.1% and output can be limited to any value from 0 to 5 amps through a front panel selector. Overshoot is not measurable thus insuring instantaneous protection to rated components and external circuitry. Recovery is better than 50 usec. and ripple and noise less than 1 mv. at full load.

Circle 124 on Reader Service Card

Register Assembly

Di-An-Controls offers a new Model Tra-25-10 Thimble Register Assembly. The register consists of ten "Thimble" core-transistor shift register elements, connected as a serial shift register, driven by one "Thimble" core-transistor shaper-driver element. Test-points are provided for observation of all pertinent waveforms. The user need only supply pulse signals in the range of 0-25KC, and a −12 volt power supply. (Higher frequency models, up to 250KC, are available.) The unit is intended to permit evaluation of the core-transistor register, for many applications in computers, data processors, industrial controls, telemetry, etc.

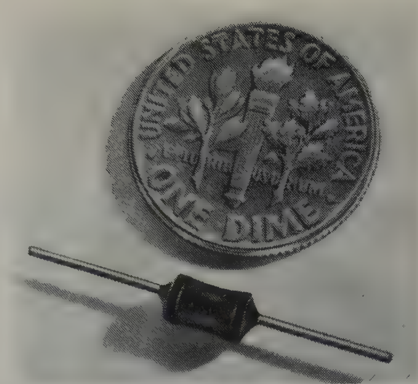
Circle 126 on Reader Service Card

Silicon Replacement Rectifier

Rated at 1600 volts peak inverse and 500 ma. d.c., the Sarkes Tarzian Type S-5207 Silicon Rectifier will replace up to 5 type 6X4 tubes in parallel. Pin connections are identical so the units are interchangeable. Rugged construction and characteristic long life found in silicon rectifiers makes type S-5027 an ideal replacement or original equipment item.

Circle 137 on Reader Service Card

Wire Wound Resistor

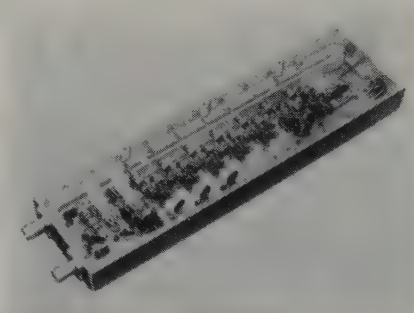


A small precision wire wound resistor has been announced by The Daven Company. Measuring 1/8" (±1/64") in diameter and 1/4" (±1/32") in length, the new micro-miniature unit, Daven Type 1282, meets all requirements of MIL-R-93B except physical size. Has axial leads, but is also available with radial leads and in this form will be known as Daven Type 1282-R. Type 1282 exhibits the following characteristics. Minimum resistance: 10 ohms. Maximum resistance: 100K ohms. Tolerances available: 10 ohms to 100 ohms, .5%; 100 ohms to 10K ohms, .25%; and 10K ohms to 100K ohms, .1%. Maximum voltage is 100 volts. Its wattage rating is .05 W at 125°C derated to zero at 145°C.

Circle 110 on Reader Service Card

Transistorized Amplifier

This latest addition to the LEL series 80 transistorized I.F. Amplifiers is a low noise hybrid unit IF81 combining the low noise properties of a tube input circuit with the low power requirements and ruggedness of transistors. Typical electrical specifications are as follows: center frequency 30 or 60 mc, bandwidths available from one to twenty mc, gain 100 db and noise figures as low as 1 db.

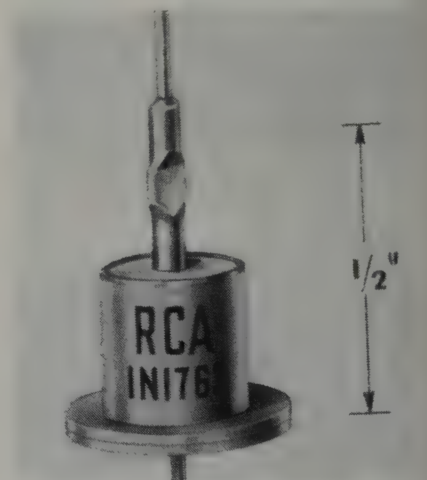


Circle 138 on Reader Service Card

New Silicon Rectifiers

1N1763 and 1N1764 diffused-junction rectifiers are enclosed in a metal envelope having welded hermetic seals. Initial units of a new line of RCA Silicon Rectifiers, these types are designed for use in power supplies of color and black-and-white television receivers, radio receivers, phonographs, and other electronic equipment. 1N1763 has a peak inverse voltage rating of 400 volts, a dc forward current rating of 500 milliamperes, and a maximum reverse current of 100 microamperes (at rated peak inverse voltage and ambient temperature of 25°C). 1N1764 has a maximum peak inverse voltage rating of 500 volts.

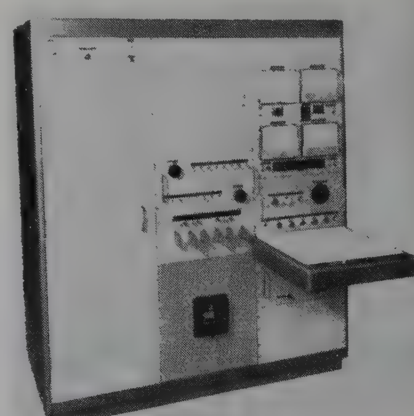
Circle 113 on Reader Service Card



Rectifier Test Set

A new laboratory and production Rectifier Test Set, designed specifically to evaluate the dynamic characteristics of silicon rectifiers in accordance with the latest ASESA recommendations, is now being offered by Wallson Associates. Model 128A employs a special simulator circuit which permits selecting any forward current or reverse voltage within its ratings. Tests rectifiers with average forward current ratings between 1 and 500 amperes half-wave and reverse voltage ratings to 2 KV peak.

Circle 129 on Reader Service Card



Miniature Selenium Rectifier

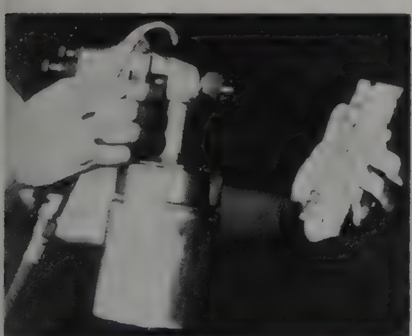
Bradley Semiconductor Corp. has designed a miniature selenium rectifier that meets military environmental specs and performs efficiently over a wide temperature range, up to 125°C. Case length is ⅝" for 10 to 30 volt units and 17/32" for 40 to 80 volts, with 1½" leads. Peak inverse voltage ranges from 37-296 at 1 ma, with .200 ma reverse leakage at 25°C ambient. Nylon seal resists humidity, salt spray, and fungus growth.

Circle 146 on Reader Service Card

Ultra High Temperature Surface Coating

Emerson & Cuming announces Eccocoat C 26, a clear epoxide surface coating which has exceptional high temperature properties. It can be used continuously at 500°F. and for short periods up to 600°F. Surface resistivity is above 10^{15} ohms at room temperature and remains about 10^{14} even at 500°F. Applied by dip, brush, or spray. Multiple coats are used in order to build up thickness. A maximum of 7 mils should be applied in a single coat. It is used for coating printed circuit boards, electronic circuits and components, metals and ceramics.

Circle 128 on Reader Service Card



Low Noise Performance Diodes

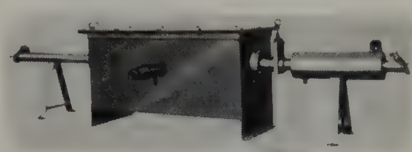
Noise temperatures as low as 50° above absolute zero for a diode cooled by liquid nitrogen, and only 100° above absolute zero operating at room temperature have been obtained by Hughes Aircraft Company in a high gain 3000 megacycle parametric amplifier using sample diodes of a newly developed type. The diode is the heart of the parametric amplifier but also has other important microwave applications such as switching and harmonic generation. It is available in two rugged and hermetically-sealed versions, one for the region below 1000 megacycles and a second for the microwave region.

Circle 145 on Reader Service Card

High Temperature Furnace

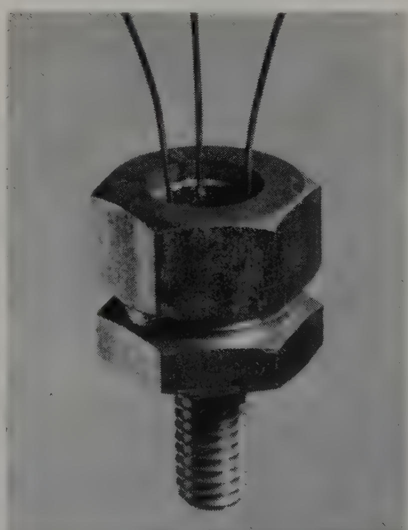
Temperatures to 5000°F can be rapidly reached and uniformly maintained throughout the heated length of new Hevi-Duty carbon-resistor tube furnaces. These furnaces are available in 6 standard sizes ranging from 1" x 12" to 5" x 48" (dimensions refer to internal heated length). Close control and regulation of furnace temperatures are assured by the use of a fully automatic saturable reactor control system. Only two hours is required to reach 5000°F. Gates on both ends of the heated zone minimize radiation losses into the charge chamber and cooling chamber. Terminal contact losses are eliminated by a machined fit of the graphite terminals to the graphite heating tube. Request Bulletin 858.

Circle 144 on Reader Service Card



Stud Mounted Heat Sinks

Availability of an insulated stud mounted heat sink for medium power transistors was announced by Jadaro Machine Products. Known as the #1101-A, it provides a practical and efficient means of heat sinking transistors in the JETEC 30 round welded packages. Can be easily attached to the transistor by the user, converting the transistor to a double ended package. Firmly tightening the gland nut provides good thermal and mechanical contact between transistor and heat sink. Heat dissipated in the transistor is conducted to the chassis through the 10-32 stud.

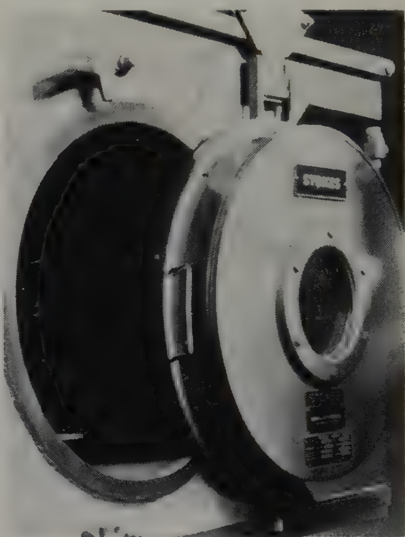


Circle 107 on Reader Service Card

Special Vacuum Equipment

Specially designed equipment for outgassing and sealing of semiconductor components under vacuum will be demonstrated at the 1959 Radio Engineering Show by F. J. Stokes Corp. Stokes will also exhibit its new series of small compound high vacuum pumps, in the 2 to 3 cfm. range, which are suitable for a number of electronic manufacturing and testing operations, such as small vacuum-impregnation systems for capacitors, transformers, and the like; small vacuum-metallizing units; and evacuating environmental testing chambers.

Circle 134 on Reader Service Card



Polycrystalline Silicon

Super-Grade pure polycrystalline silicon Trancoa Grade 1A, is now available from Trancoa Chemical Corp. The new super-grade silicon will enable semiconductor manufacturers to produce special devices on a practical basis using standard crystal growing techniques. Grade 1A silicon is one of five grades of polycrystalline silicon being produced by Trancoa.

Circle 119 on Reader Service Card

Glass Coating

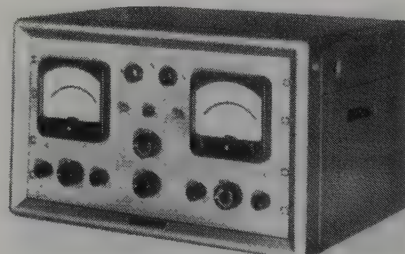
High-purity low-melting glass for coating electronic devices is now available from Baker & Adamson, General Chemical Div., Allied Chemical Corp. These new, low-melting glasses promise an ideal coating for protecting germanium and silicon transistors and diodes from atmospheric oxidation, contamination and humidity. Coating may be accomplished by simply dipping the devices in a fluid bath of the glass, withdrawing and cooling; or through the use of a preform (compressed powder).

Circle No. 152 on Reader Service Card

New Megatrometer

Mid-Eastern Electronics announces a new Megatrometer, Model 710, for the measurement of resistance values to 5,000 million megohms. Accuracy in the upper half scale is ±3.0%. The unit is portable and incorporates its own transistorized power supply for test potentials to 1,000 V d.c., continuously variable. Mercury cells provide voltage stability with less than 0.0005% change per hour at 1,000 Volts.

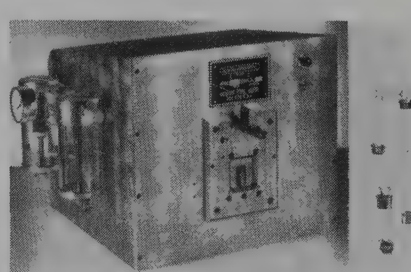
Circle 127 on Reader Service Card



Transistor Lead Straightener

Electro-Machinery Division of Design Tool Corp. has introduced a new Radia-lead Straightener, Model AL3NS, an all purpose machine for automatically straightening, cutting and preforming the leads of transistors. From a specific job, a quick simple change of head will adapt the machine to serve a new job function. It will automatically straighten and align leads to the proper center distance so that the components will always exactly match the holes in the printed board.

Circle 133 on Reader Service Card



Interchangeable Matched Thermistors

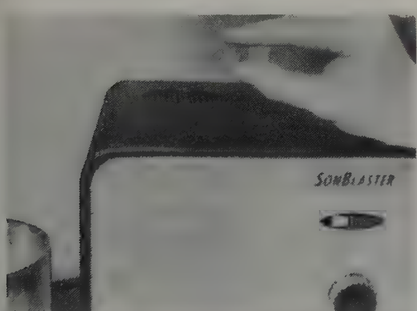
A new line of interchangeable and close tolerance matched thermistors is announced by Victory Engineering. The more than 30 new units are classified in five major groups, each representing a specific type of matching: resistance matching, voltage matching, series-parallel matching, resistance-temperature matching, and resistance ratio-temperature matching.

Circle 109 on Reader Service Card

Ultrasonic Cleaning

Narda Sonblaster Model G-201 generator with a Model NT-201 ⅛-gallon stainless steel tank is currently being used for Ultrasonic cleaning of delicate radio crystals used in the electronic industry. The crystals are wafers of etched quartz, very small in size, and are handled in batches of 50 in a wire mesh basket specially designed for efficient transmission of acoustic energy through the walls of the basket. Total cleaning and rinsing time is 8 to 10 minutes.

Circle 150 on Reader Service Card



New Diode and Transistor Lines

Pacific Semiconductors announces 8 new types of semiconductor devices. These include PSI Types XT-515 through XT-520 NPN Triple-Diffused Silicon Mesa Transistors. PSI also offers a line of fast recovery Silicon Diffusion Computer Diodes featuring hermetically sealed construction and type numbers designated by color bands on the body, reading from the cathode end.

Circle 151 on Reader Service Card

Electrolytic Moisture Analyzer

Electronics manufacturers can monitor air drying equipment and determine the moisture content of dry boxes down to one part per million by volume with the Meeco Model W Electrolytic Moisture Analyzer manufactured by Manufacturers Engineering and Equipment Corp. Moisture content is indicated directly; no computation or conversion is necessary. Completely integrated unit including both flow regulating and measuring components.

Circle 141 on Reader Service Card

(*Continued on page 67*)

✓ Industry News

Factory sales of transistors in December increased substantially over November to establish an all-time high sales level for transistors in any given month in the history of the industry, according to the Electronic Industries Association. Unit sales of transistors during 1958 increased by sixty-four percent over sales in 1957.

Factory sales of transistors in December totaled 5,627,700 valued at $16,595,616 compared with 5,440,981 units valued at $12,441,759 sold in November and 2,773,000 units valued at $6,619,000 sold in December 1957.

Cumulative sales of transistors during 1958 totaled 47,050,814 valued at $112,729,427 compared with the 28,738,000 transistors valued at $69,739,000 sold during calendar year 1957.

The following EIA chart shows factory sales and the dollar value of transistors in December and calendar year 1958:

	1958 Sales (units)	*1958 Sales (dollars)*	*1957 Sales (units)*
January	2,955,247	$6,704,383	1,436,000
February	3,106,708	6,806,562	1,785,300
March	2,976,843	6,795,427	1,904,000
April	2,856,234	7,025,547	1,774,000
May	2,999,198	7,250,824	1,055,000
June	3,558,094	8,232,343	2,245,000
July	2,631,894	6,598,762	1,703,000
August	4,226,616	9,975,935	2,709,000
September	5,076,443	10,811,412	3,231,000
October	5,594,856	13,461,847	3,544,000
November	5,440,981	12,441,759	3,578,700
December	5,627,700	16,595,616	2,773,000
TOTAL	47,050,814	$112,729,427	28,738,000

A radically new cool-running radio tube (recently demonstrated in New York), considered the first major break-through in basic tube design in more than 30 years, was unveiled recently by the Department of the Army. The new device has been developed jointly by the U. S. Army Signal Corps and Tung-Sol Electric Inc. In the new tube, the hot element is replaced by a cold cathode—a tiny nickel cylinder specially coated with porous magnesium oxide (chemically identical to dried milk of magnesia). Instead of heat, a high voltage field causes the electron flow, which in turn produces the tube's characteristic phosphorescent blue glow.

Tomorrow's physical check-up may be performed by an electronic machine that will diagnose a case in 30 seconds and present its findings on a 3 x 5 punch card. The 'electronic doctor' will probably be similar to a pilot's wired space suit, according to Irwin Steinberg, general manager, Vibro-Ceramics Division, Gulton Industries, Inc., Metu-

chen, N.J. The new medical electronic system contains medical instruments which measure breathing rate, heart rate, body temperatures, blood pressure and skin resistance. The instruments were developed to gather medical information without a doctor, since it will be impossible to send a doctor up in each space ship to find out what is happening to the pilot.

The following price reductions have been announced: Sprague Electric Company, North Adams, Mass., has decreased by another 10% the price of their Type 150D series Tantalex Capacitors. Raytheon Mfg. Company has lowered by 5 to 20% the prices of their transistor types 2N404, 2N425, 2N426, 2N427, 2N428, and 2N1017. The Hi-Q Division of Aerovox Corp., Olean, New York has reduced by 10% the price of Cerafil capacitors.

A move to new and enlarged plant quarters at 3322 Hudson Ave., Union City, N.J. was announced as completed on January 30, 1959, by Mr. Eli Stiefel, partner and general manager of Kahle Engineering Company.

Texas Instruments Incorporated President P. E. Haggerty recently announced the start of construction on a 192,000 sq ft addition to the present 310,000 sq ft Semiconductor-Components division plant. The addition will be made to the south end of the existing plant which was the first building erected on TI's 300-acre site on North Central Expressway in northeast Dallas. With completion of the addition in approximately 12 months, TI will have more than 500,000 sq ft of modern manufacturing, development and administration space devoted to the design and production of semiconductor devices.

Sprague Electric Company, North Adams, Mass., has purchased the magnetic component and filter product lines of the Hycor Division of the International Resistance Company of Philadelphia, Pa., it was announced jointly by both companies. Sprague will take over the manufacture of the various Hycor products lines including magnetic amplifiers; saturable reactors; high frequency electronic power transformers; toroids; decade inductors; low-pass and pecision band-pass filters for communication, telephone and sound recording applications; telemetering filters; and broadcast and sound recording program equalizers which were formerly made by the IRC Division at its Sylmar, Calif. plant. The IRC Hycor Division will continue its manufacturing operations on precision resistors, which are not involved in the sale to the Sprague company.

The first transistor made in the Findlay, Ohio RCA Plant came off the production line on Feb. 5, 1959, it was announced by John M. Spooner, Manager of the local RCA Semiconductor and Materials Division's plant. "At first," Mr. Spooner said, "the Findlay plant will turn out several different transistors designed for use in radio sets, phonographs and stereophonic instruments. Later in the year, we will introduce other transistors specifically designed for automobile radios."

The 1959 Electronic Components Conference will be held at the Benjamin Franklin Hotel, Philadelphia, Pa. on May 6, 7, 8, 1959.

The 1959 IRE National Convention, to be held at the New York Coliseum and Waldorf-Astoria Hotel March 23-March 26 will feature many interesting papers on

semiconductor materials, devices, applications and techniques. Following are some of the papers:

6.3 A Semi-Automatic Transistor Testing Machine
Ed Millis, Texas Instruments, Inc.

8.1 The Field Effect Tetrode
H. A. Stone, Jr., Bell Telephone Labs

8.3 A Simple and Flexible Method of Fabricating Diffused NPN Silicon Power Transistors

8.4 A Twenty Ampere Switching Transistor
T. P. Nowalk, Westinghouse Electric Corp.

8.5 Drift Considerations in Low Level Direct-Coupled Transistor Circuits
J. R. Biard & W. T. Matzen, Texas Instruments, Inc.

10.1 A Transistorized Nuclear Reactor Count Rate Channel
J. H. Cawley, General Atomic Div., General Dynamics Corp.

10.2 Transistorized Source-Range Reactor Instrumentation
R. R. Hoge, Bendix Aviation Corp.

10.4 A Transistorized Pulse Height Analyzer
R. T. Graveson, U. S. Atomic Energy Commission

11.4 Transistorized Video Switching
J. W. Wentworth, C. R. Monro & A. C. Luther, Jr., RCA

11.5 A New Approach to Low Distortion in a Transistor Power Amplifier
H. J. Paz, RCA

16.1 Ferrites and Microwave Solids
C. L. Hogan, Motorola

16.2 Solid State Energy Sources
W. J. Vander Grinten, General Electric

16.3 Advanced Semiconductors
W. M. Webster, Jr., RCA

18.1 A Transistorized Cold Cathode Decade Counter
Henry Sadowski & M. E. Cassidy, U.S. Atomic Energy Comm.

18.2 A High Sensitivity Semiconductor Diode Modulator for D. C. Current Measurement
H. E. DeBolt, Fairchild Camera & Instrument Corp.

20.4 The Application of the Silicon Capacitor in Automatic Sweep Circuits and "Signal Seeking" Receivers
J. Black, El Segundo, Calif.

20.5 An Analysis of a Transistorized Class "B" Vertical Deflection System
Z. Wiencek & J. E. Bridges, Warwick Mfg. Corp.

21.3 Transistor Waveform Generators
G. N. Webb & R. N. Glackin, Johns Hopkins Hospital

26.1 Considerations in Transistor Automobile Receiver Front End Design
R. Martinengo, Raytheon Mfg. Co.

26.2 A Five Transistor Automobile Receiver Employing Drift Transistors
R. A. Santilli & C. F. Wheatley, RCA

26.3 Improvements in Detection, Gain Control, and Audio Driver Circuits of Transistorized Broadcast Band Receivers
R. V. Fournier & D. Thorne, RCA

39.2 Noise Figure of Receiver Systems Using Parametric Amplifiers
J. Sie & S. Weisbaum, RCA

39.3 Low Noise Parametric Amplifiers and Converters
T. B. Warren, ITT Laboratories

39.4 Microwave Techniques in Measurement of Lifetime in Germanium
A. P. Ramsa, Monmouth College

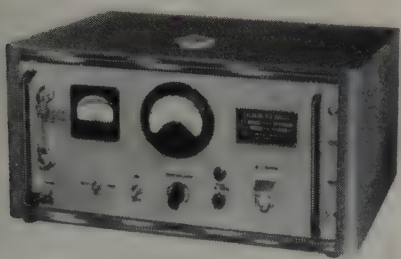
49.5 Transistor Digital Tape Record Circuit
A. E. Hayes, Jr., Ampex Corp.

New Products
(from page 63)

Calorimeter Bridge

Electro Impulse Lab announces direct reading Calorimeter Bridge, Model CB-16. Completely self-contained with its own circulating system, cooling system and radio frequency dummy load and requires only connection to the regular power line. R.F. power is read directly on a 4½" meter in watts. Single coaxial dummy load is available to cover the frequency range from DC to 10,000 Mc and for the power range from 1 to 1,000 watts.

Circle 143 on Reader Service Card



Transistor Batteries

Olson Radio Warehouse announces two new 9 volt transistor batteries, models BA-48 and BA-50. Both have snap-type polarized connectors. BA-48 is 1" in diameter x 2" long including terminals. BA-50 is 1-15/16" x 1" x 5/8". These batteries are designed for use in most portable and transistor radios and R/C equipment.

Circle 118 on Reader Service Card

Power Supplies

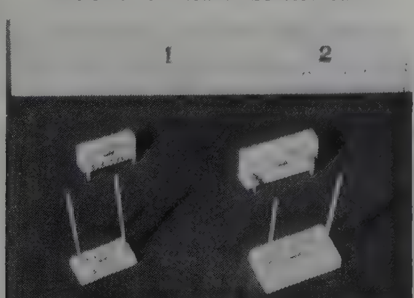
Transistorized, short circuit proof, power supplies announced by Electronic Measurements cover a complete range starting at zero. They can be used from a fraction of one volt to any voltage up to 60 without loss of regulation or stability. Three models are available with maximum current ratings of 2.5A, 5A, and 7.5A. Regulation is 0.1% or 0.01 volts from no load to full load and with 105 to 125 volt lines. All units are for standard rack mounting but have four rubber feet for table mounting.

Circle 132 on Reader Service Card

Ultra Miniature Capacitor

Radial-lead CY17C Vitramon Capacitor brings capacity values in the Radial Series to 1200 mmf at 50 to 300 vdcw. Features an exceptionally thin design (5/64 in.) whose lead geometry permits axial, radial or edge mounting. One thousand of the smallest of this series occupy a space of approximately six cubic inches, making them particularly useful in minute circuit assemblies.

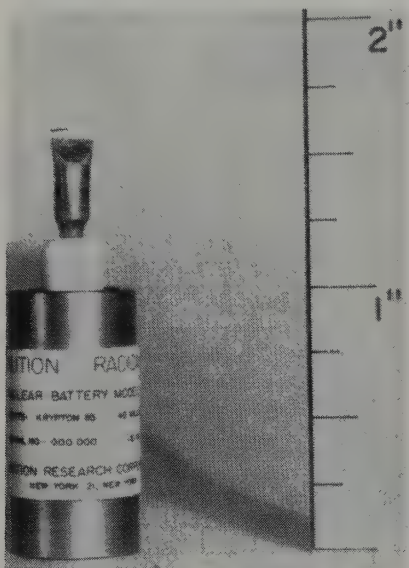
Circle 108 on Reader Service Card



Nuclear Batteries

Radiation Research Corporation announces the availability of Krypton batteries producing output potentials greater than 5 KV in a volume less than one-quarter of one cubic inch and free from any radiological ingestion hazard. To overcome toxicity problems, the radioisotope Krypton 85 has been substituted for Strontium 90. Krypton is not metabolized in any way by the body; therefore, batteries using Krypton are hazardous only if unshielded. If a Krypton battery is accidentally opened the Krypton dissipates harmlessly into the atmosphere.

Circle 147 on **Reader Service Card**



Power Silicon Rectifiers

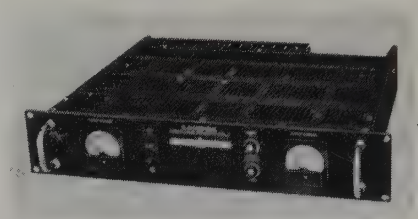
A new line of silicon power rectifiers has been introduced by Vickers, Inc., offering reliability and uniformity. The new rectifier features diffused silicon junction; solid copper base, hot tin dipped terminal; hermetic seal for silicon chamber, and tough epoxy protective coating.

Circle 114 on Reader Service Card

Transistorized Power Supply

An all-transistor power supply with a range of 0-1 AMP is being produced by Lambda Electronics. Unmetered model (LT 1095), with meters (Model LT 1095M), this new unit duplicates Lambda's 2-AMP model with the exception of the voltage range. Like the 2-AMP, it is convection cooled with no moving parts, no internal blowers. Voltage range is 0-32 VDC.

Circle 115 on Reader Service Card



Copper Sealing Glass

A new pressed and sintered glass which can be directly sealed to copper with an expansion-match seal has been introduced by Corning Glass Works. Code 7295 copper sealing Multiform glass, according to Corning, fulfills a long-standing need of the electronics industry where copper is desirable as a lead and component material for tubes, semiconductors and other devices. Using presently known sealing techniques, the glass can be hermetically fused directly to copper.

Circle 131 on Reader Service Card

Standard Resistor Line

Mid-Eastern Electronics offers a line of certified Laboratory Standard Resistors for use with the company's Megatrometer in measuring resistance in the ultra high megohm range. Available in four values: 10 megohms, 100 megohms, 1,000 megohms and 10,000 megohms. Each unit is certified to 0.2% and is supplied with a temperature curve. They supplement the company's line of Reference Resistors offered in values from 1,000 megohms to 10 million megohms certified within 1.0%.

Circle 149 on Reader Service Card

D.C. Power Supply

Model PS-2 dual purpose filtered D.C. Power Supply has been announced by Electro Products Laboratories. The new power supply powers transistor circuits, hybrid sets, 12/6 volt auto radios without hum. Two output ranges are provided: 0 to 20 volts at a rating of 75 MA for operating transistor circuits, and 0 to 16 volts with a rating of 5 amperes for operating 12/6 volt radios and hybrid sets. A special pi-type input filter holds ripple down to 0.15% up to 75 milliamperes (well below the critical requirement for low current loads in servicing transistor radios) and 0.5% up to 5 amperes. A separate milliameter for each range detects minute variations in transistor current. Each range has its own output terminals.

Circle 104 on Reader Service Card

New Literature

A two-page bulletin describing the technical features of the Model 1002 Cathode Ray Indicator, has been published by Technitrol Engineering Company. The bulletin describes an X-Y coordinate indicating device having identical high gain DC- coupled amplifiers on both the horizontal and vertical axes. The sensitivity and bandwidth of these amplifiers permit the instrument to be used in a number of applications where sweep voltages are provided by external test equipment. The bulletin includes all physical and electrical specifications of the instrument along with the price.

Circle 56 on Reader Service Card

Navigation Computer Corp. announces a new booklet entitled "Notes on Transistor Switching Circuitry." This 16-page booklet covers the field of transistorized pulse handling techniques, and includes diagrams for programming pulses, delays serial to parallel conversion (and vice-versa), ring counters, cycle distributors, binary counting, electronic switching, etc.

Circle 57 on Reader Service Card

A new Glass-to-Metal Seals booklet, is announced by The Carborundum Co. It describes Kovar alloy type matched expansion seals, compression seals and graded tubular seals. Also included are designs and sizes of those parts available for stock delivery.

Circle 58 on Reader Service Card

A 16-page catalog published by International Rectifier Corporation gives ratings, electrical characteristics and descriptive data on 405 types of silicon and selenium rectifiers and diodes. Specifications cover more than 140 types of silicon rectifiers (including 63 zener diode types), 47 silicon cartridge rectifiers, and more than 130 selenium rectifier and contact protector types.

Circle 59 on Reader Service Card

Titled "Extruded TFE Teflon Tubing" a new bulletin describes and illustrates the full line of CDF Teflon Tubing. Complete tables of sizes and tolerances are given. This brochure also presents in tabular form complete lists of electrical and physical properties of the tubing. The test method is indicated for each property.

Circle 60 on Reader Service Card

Arenberg Ultrasonic Laboratory, Inc., announces a 35-page mimeographed manual on "Procedures For Testing Ultrasonic Delay Lines" which covers basic inspection, single terminal impedance measurements, overall insertion loss, band width, ripples in the band pass, secondary signals, multiple travel signals, direct feed through, sum of secondaries, delay time, absorption in medium, temperature effects and other variables, such as military requirements. Applications to high speed computers, radar MTI and integration kits, as well as timing devices are considered.

Circle 61 on Reader Service Card

A three-color report entitled "How To Appraise Sonic Energy Cleaning" has been published by the Pioneer-Central division of Bendix Aviation Corporation. The publication is a concise presentation of up-to-the-minute facts on sonic energy applications in industry. It explains how sonic energy can be applied sufficiently for cost reduction and product improvement. The material is divided into five main subjects: what sonic energy is; how it cleans; how its cleaning efficiency can be evaluated; an analysis of a new concept in sonic energy applications; and an outline of the application engineering services of the division designed to help potential users to determine the feasibility of applying sonic energy to specific jobs.

Circle 53 on Reader Service Card

Bulletin 115, a listing of six basic Duramic Hi-temperature tooling materials, their properties, availability, and principal applications, acting as a handy guide to tool and process engineers in selecting the right material for their hi-temp work, is available at no charge from Duramic Products, Inc. These materials offer a range of properties for applications up to 3000 deg. F., such as induction brazing jigs, semiconductor alloying jigs, projection and arc welding tools, furnace parts and fixtures, torch brazing jigs, ferrite and powder metal sintering boats, glass working tools, hot forming dies, and heat treating fixtures.

Circle 54 on Reader Service Card

A four-page catalog, describing a new line of off-the-shelf high temperature ceramic tool components, including a wide variety of bushings, washers, discs, plates, rods, and v-blocks, is now available at no charge from Duramic Products, Inc. Bulletin 116 includes information on dimensions, tolerances, how to order special requirements, and complete mechanical and electrical properties of the hi-temp ceramic components. Using this catalog, design and production engineers can now utilize off-the-shelf components which can be obtained rapidly for such applications as hi-temp fixtures for brazing, soldering, welding, sintering, melting or hot forming operations.

Circle 55 on Reader Service Card

Microtran Company, Inc., has just issued a new short form catalog listing complete specifications on the company's products. These include miniature, subminiature, transistor, MIL-T-27A and industrial transformers that are available from distributor stock. The short form catalog serves as a ready reference for a quick run-down on the transformers offered by Microtran, showing the wide range of models at a glance.

Circle 69 on Reader Service Card

PCA Electronics, Inc. has published a new 24-page catalogue titled "Pulse Transformers" and designed to assist engineers in the application of transformers to their specific needs. Complete with many tables, charts, and schematics this manual covers a brief history of low-level pulse transformers, their measurements, specifications, applications, interchangeability, dielectric ratings, manufacturing, and other data.

Circle 70 on Reader Service Card

Just off the press, Lambda's new 36-page catalog contains information and specifications on the company's full line of transistor-regulated and tube-regulated power supplies. In addition, the brochure explains the background of Lambda's Five-Year Guarantee and gives detailed outline drawings of the equipment.

Circle 71 on Reader Service Card

Sarkes Tarzian, Inc., announces a new two color, forty-eight page silicon rectifier handbook containing electrical ratings, performance data and dimensional drawings for every type of silicon rectifier offered by the firm. This 1959 handbook also deals with silicon rectifier theory of operation, manufacture and characteristics and offers the design engineer valuable help in silicon rectifier application.

Circle 72 on Reader Service Card

A detailed listing of the properties, forms and composition of wrought copper and copper-base alloys is available in a 14-page booklet issued by Western Brass Metals Division, Olin Mathieson Chemical Corporation. Easy-to-read reference sheets list the nominal composition, available forms and physical properties of the alloys. Tensile, yield and shear strength, and elongation of the alloys, both hard and soft, are also included. Ratings for the corrosion resistance, as well as the hot working and annealing range, and fabricating properties are also featured.

Circle 52 on Reader Service Card

A six-page brochure, "High Vacuum Technology and the Space Age," of interest to high altitude aircraft and missile industry design engineers and technical management is available from National Research Corporation. It includes an 11" x 17", three-color Upper Atmosphere Vacuum Spectrum Chart developed by the NRC staff using latest available International Geophysical Year satellite data as well as information from other recently published literature. The chart permits rapid determination of atmospheric density, temperature, pressure and mean free path of gas molecules up to an equivalent altitude of 600 miles.

Circle 74 on Reader Service Card

Bulletin 106 (16 pages, 2-color) illustrates and describes the design approach, materials, construction and modern facilities used in manufacturing a variety of Centralized Control and Data Presentation Systems. Available without cost from Panellit, Inc.

Circle 75 on Reader Service Card

A microhardness tester that permits direct, accurate readings, corresponding to Vickers, within 15 seconds by measuring resistance hydrostatically and which eliminates a microscope, conversion charts and complicated tables is illustrated and described in a two-color bulletin recently issued by Newage Industries, Inc. According to the manufacturer, many production and precision parts that could not be checked before can now be tested with accuracy including small wire, tips of cutting tools, surgical needles, wire punches, and thin sheet stock.

Circle 76 on Reader Service Card

(*Continued on page 76*)

CHARACTERISTICS CHART of NEW TRANSISTORS

MANUFACTURERS (In Order of Code Letters)

ARA— Advanced Research Associates, Inc.
AMP— Amperex Electronic Corp.
BEN— Bendix Aviation Corp.
BOG— Bogue Electric Mfg. Co.
BTHB— British Thomson-Houston Export Co., Ltd.
CBS— CBS-Hytron
CTP— Clevite Transistor Products, Inc.
DEL— Delco Radio Div., General Motors Corp.
EEVB— English Electric Valve Co., Ltd.
ESEB— Edison Swan Electric Co., Ltd.
FCS— Fairchild Semiconductor Corp.
FTHF— French Thomson-Houston Semiconductor Dept.
GECB— General Electric Co., Ltd.
GE— General Electric Co.
GEM— Great Eastern Mfg. Co.
GTC— General Transistor Corp.
HUG— Hughes Aircraft Co.
HIVB— Hivac Ltd.
IND— Industro Transistor Corp.
LCTF— Labortoire Central de Telecommunications
MIN— Minneapolis-Honeywell Regulator Co.
MOT— Motorola, Inc.
MUL— Mullard Ltd.
NTLB— Newmarket Transistors Ltd.
NPC— Nucleonics Products Co.
PSI— Pacific Semiconductors, Inc.
PHI— Philco Corp., Landsdale Tube Co.
RAY— Raytheon Mfg. Co.
RCA— Radio Corp. of America, Semiconductor Div.
SIE— Siemens & Halske Aktiengesellschaft
SONY— Sony Corp.
SPE— Sperry Gyroscope Co.
SPR— Sprague Electric Co.
SYL— Sylvania Electric Products Inc.
STCB— Standard Telephone & Cables, Ltd.
TKAD— Suddeutsche Telefon-Apparate-, Kabel und Drahtwerke
TRA— Transitron Electronic Corp.
TFKG— Telefunken Ltd.
TI— Texas Instruments
TUN— Tung-Sol Electric, Inc.
WEC— Western Electric Co., Inc.
WEST— Westinghouse Electric Corp.

CHARACTERISTICS CHART of NEW TRANSISTORS

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C: P_c (mw)	DERATING °C/W	V_{CB}	V_{CE}	Typical Characteristics: $f_{\alpha\beta}$ (mc)	Gain: PARAMETER and (condition)	VALUE	MFR. See code at start of charts
2N213A	2	NPNA	Ge	150	400	40	25	.15	Pg	40db	SYL
2N315A	2,5	PNPA	Ge	150	500	30		5.0	h_{FE}:I_C-100ma	35	GTC,IND
2N316A	2,5	PNPA	Ge	150	500	30		12	h_{FE}:I_C-200ma	35	GTC,IND
2N317A	2,5	PNPA	Ge	150	500	25		20	h_{FE}:I_C-400ma	40	GTC,IND
2N356A	2,5	NPNA	Ge	150	500	30		3.0	h_{FE}:I_C-100ma	35	GTC
2N357A	2,5	NPNA	Ge	150	500	30		6.0	h_{FE}:I_C-200ma	40	GTC
2N358A	2,5	NPNA	Ge	150	500	30		9.0	h_{FE}:I_C-300ma	40	GTC
2N444A	2,5	NPNA	Ge	150	500	40		.50Ø	h_{FE}:I_C- 20ma	30	GTC
2N445A	2,5	NPNA	Ge	150	500	30		2.0Ø	h_{FE}:I_C- 20ma	90	GTC
2N446A	2,5	NPNA	Ge	150	500	30		5.0	h_{FE}:I_C- 20ma	150	GTC
2N447A	2,5	NPNA	Ge	150	500	30		9.0Ø	h_{FE}:I_C- 20ma	200	GTC
2N519A	2,5	PNPA	Ge	150	500	25		.50Ø	h_{FE}:I_C- 20ma	35	GTC,IND
2N520A	2,5	PNPA	Ge	150	500	25		3.0Ø	h_{FE}:I_C- 20ma	100	GTC,IND
2N521A	2,5	PNPA	Ge	150	500	25		8.0Ø	h_{FE}:I_C- 20ma	150	GTC,IND
2N522A	2,5	PNPA	Ge	150	500	25		15Ø	h_{FE}:I_C- 20ma	200	GTC,IND
2N523A	2,5	PNPA	Ge	150	500	25		21Ø	h_{FE}:I_C- 20ma	250	GTC,IND
2N561	3,5	PNP	Ge	50W	1.5	80	50	6.5KcΔ	h_{FE}:I_C- 1A	75	RCA
2N616A	2	PNPF	Ge	125	480	20		9.0	h_{fe}:I_e- .5ma	25	WEST
2N617A	2	PNPF	Ge	125	480	20		7.5	h_{fe}:I_e- .5ma	15	WEST
2N1000	2,5	NPNA	Ge	150	500	40		7.0Ø	h_{FE}:I_C-100ma	35	GTC
2N1008	2,5	PNP	Ge	400	150	20	20	1.0	h_{FE}:I_C- 10ma	95	BEN
2N1008A	2,5	PNP	Ge	400	150	40	40	1.0	h_{FE}:I_C- 10ma	95	BEN
2N1008B	2,5	PNP	Ge	400	150	60	60	1.0	h_{FE}:I_C- 10ma	95	BEN
2N1010	1	NPN	Ge	20		10	10	2.0	h_{fe}:I_c-.30ma	35	RCA
2N1012	2,5	NPNA	Ge	150	500	40		3.0Ø	h_{FE}:I_C-100ma	50	GTC
2N1014	3,5	PNP	Ge	50W	1.5	100	65	6.5KcΔ	h_{FE}:I_C- 1A	75	RCA

NOTATIONS

Under Use

1—Low power a-f equal to or less than 50 mw
2—Medium power a-f > 50 mw and equal to or less than 500 mw
3—Power > 500 mw
4—r-f/i-f
5—Switching & Computer

Under Type No.

A—Alloyed
D—Diffused or Drift
G—Grown
H—Hook Collector
M—Microalloy
O—Other
P—Previously released with new specs
S—Surface Barrier
UNI—Unijunction Transistor
Y—Symmetrical

Under $f_{\alpha b}$

* Maximum Frequency
# Figure of Merit
Δ $f_{\alpha e}$
Ø minimum

From Transistor Center, U.S.A. ...

PHILCO®

announces a new family of LOW COST Medium Power Alloy Junction Transistors

Introducing a completely new family of PNP germanium transistors, especially designed to meet rigid military and industrial specifications . . . at lowest possible prices.

These transistors are available in production quantities, for use in teletypewriters, control amplifiers, ignition systems, mobile radios and desk calculators (2N1124); servo amplifiers, voltage regulators and pulse amplifiers (2N1125, 2N1126, 2N1127); medium power audio and switching applications (2N1128, 2N1129, 2N1130).

Also available in quantities 1-99 from your local Philco Industrial Semiconductor Distributor.

Make Philco your prime source of information for all transistor applications. Write to Lansdale Tube Company, Division of Philco Corporation, Lansdale, Pa., Dept. SC 359.

TYPE	V_{CB} Max. (Volts)	V_{CE} Max. (Volts)	Peak I_C (Amps)	P Max. (Watts)	$f_{\alpha b}$ (MC)	Beta	Applications	PRICE
 **2N1124**	40	35	0.5	0.3	0.4 Min	h_{fe} 40 Min	For high voltage general purpose use in amplifier and switching. Small signal beta controlled.	**$ 1.30**
2N1125	40	40	0.5	0.3	1.0 Min	$\overline{h_{fe}}$ 50-150 @ 0.5 amp	For high voltage, higher frequency industrial amplifier and switching systems. Large signal beta controlled.	**$1.90**
 **2N1126**	40	35	0.5	1.0	0.4 Min	h_{fe} 40 Min	1 watt version of 2N1124 for servo amplifiers and relay actuators. Small signal beta controlled.	**$1.80**
2N1127	40	40	0.5	1.0	1.0 Min	h_{FE} 50-150 @ 0.5 amp	1 watt version of 2N1125 for servo amplifiers and control systems. DC beta controlled.	**$2.40**
2N1128	25	18	0.5	0.15	1.0	h_{fe} 70-150	For low distortion, high level driver and output application. Small signal beta controlled.	**$ .95**
 **2N1129**	25	25	0.5	0.15	0.75	h_{FE} 100-200 @ 0.1 amp	For high gain general purpose amplifier and switching. Typical DC beta 165.	**$1.10**
2N1130	30		0.5	0.15	0.75	h_{FE} 50-165 @ 0.1 amp	For higher voltage, higher level amplifier and switching applications. Typical DC beta 125.	**$ .95**

Available in Production Quantities—Also Available from Local Distributors

PHILCO CORPORATION

LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNSYLVANIA

Circle No. 33 on Reader Service Card

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CHARACTERISTICS CHART of NEW TRANSISTORS

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C				Typical Characteristics	Gain		MFR. See code at start of charts
				P_c (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha\beta}$ (mc)	PARAMETER and (condition)	VALUE	
2N1026A	2,4,5	PNPA	Si	150	830	35	35	2.0	$h_{fe}:I_e$ - 1ma	36	SPE
2N1029	3,5	PNP	Ge	50W	1.5	50	30	.50	$h_{FE}:I_C$ - 10A	40	BEN
2N1029A	3,5	PNP	Ge	50W	1.5	60	40	.50	$h_{FE}:I_C$ - 10A	40	BEN
2N1029B	3,5	PNP	Ge	50W	1.5	90	70	.50	$h_{FE}:I_C$ - 10A	40	BEN
2N1029C	3,5	PNP	Ge	50W	1.5	100	80	.50	$h_{FE}:I_C$ - 10A	40	BEN
2N1030	3,5	PNP	Ge	50W	1.5	50	30	.50	$h_{FE}:I_C$ - 10A	75	BEN
2N1030A	3,5	PNP	Ge	50W	1.5	60	40	.50	$h_{FE}:I_C$ - 10A	75	BEN
2N1030B	3,5	PNP	Ge	50W	1.5	90	70	.50	$h_{FE}:I_C$ - 10A	75	BEN
2N1030C	3,5	PNP	Ge	50W	1.5	100	80	.50	$h_{FE}:I_C$ - 10A	75	BEN
2N1065	2,5	PNPD	Ge	120	500	40		20Ø	$h_{FE}:I_B$ - .5ma	50	GTC
2N1095	2	NPNG	Si	500		60	60	3.0	$h_{fe}:I_e$ - 20ma	36	BOG
2N1096	2	NPNG	Si	500		90	60	3.0	$h_{fe}:I_e$ - 15ma	35	BOG
2N1101	2	NPNA	Ge	180	278	20	15	.15	$h_{FE}:I_C$ - 35ma	40	SYL
2N1102	2	NPNA	Ge	180	278	40	25	.15	$h_{FE}:I_C$ - 35ma	40	SYL
2N1114	5	NPNA	Ge	150	500	25	15	10	$h_{FE}:I_C$ - 20ma	110	SYL
2N1122	4,5	PNPM	Ge	25	1600	15	10	40*	$h_{fe}:I_e$ - 1ma	140	PHI
2N1122A	4,5	PNPM	Ge	25	1600	15	14	40*	$h_{fe}:I_e$ - 1ma	140	PHI
2N1123	5	PNPA	Ge	750	100	45	40	4.5	$h_{FE}:I_C$ -100ma	70	PHI
2N1124	2	PNPA	Ge	300	200	40	35	1.0	$h_{fe}:I_e$ - 10ma	300	PHI
2N1125	2,5	PNPA	Ge	300	200	40	40	1.5	$h_{fe}:I_c$ -500ma	70	PHI
2N1126	2,5	PNPA	Ge	1000	60	40	35	.40Ø	$h_{fe}:I_e$ - 10ma	40min	PHI
2N1127	2,5	PNPA	Ge	1000	60	40	40	1.5	$h_{FE}:I_C$ -500ma	100	PHI
2N1128	2	PNPA	Ge	150	400	25	18	1.0	$h_{fe}:I_c$ - 2ma	100	PHI
2N1129	2	PNPA	Ge	150	400	25	25	.75	$h_{FE}:I_C$ -100ma	165	PHI
2N1130	2,5	PNPA	Ge	150	400	30		.75	$h_{FE}:I_C$ -100ma	125	PHI
2N1136	3,5	PNP	Ge	25W	2.0		40	.50	$h_{FE}:I_C$ - 3A	75	BEN
2N1136A	3,5	PNP	Ge	25W	2.0		70	.50	$h_{FE}:I_C$ - 3A	75	BEN
2N1136B	3,5	PNP	Ge	25W	2.0		80	.50	$h_{FE}:I_C$ - 3A	75	BEN
2N1137	3,5	PNP	Ge	25W	2.0		40	.50	$h_{FE}:I_C$ - 3A	105	BEN
2N1137A	3,5	PNP	Ge	25W	2.0		70	.50	$h_{FE}:I_C$ - 3A	105	BEN
2N1137B	3,5	PNP	Ge	25W	2.0		80	.50	$h_{FE}:I_C$ - 3A	105	BEN
2N1138	3,5	PNP	Ge	25W	2.0		40	.50	$h_{FE}:I_C$ - 3A	150	BEN
2N1138A	3,5	PNP	Ge	25W	2.0		70	.50	$h_{FE}:I_C$ - 3A	150	BEN
2N1138B	3,5	PNP	Ge	25W	2.0		80	.50	$h_{FE}:I_C$ - 3A	150	BEN
2N1141	3,4	PNPD	Ge		100	35		750	$h_{fe}:I_c$ - 10ma	32	TI
2N1142	3,4	PNPD	Ge		100	30		600	$h_{fe}:I_c$ - 10ma	32	TI
2N1143	3,4	PNPD	Ge		100	25		480	$h_{fe}:I_c$ - 10ma	32	TI
2N1146				70W	1.0	40	40	.04Δ	$h_{FE}:I_C$ - 15A	35	CTP
2N1146A				70W	1.0	60	60	.04Δ	$h_{FE}:I_C$ - 15A	35	CTP
2N1146B				70W	1.0	80	80	.04Δ	$h_{FE}:I_C$ - 15A	35	CTP
2N1146C				70W	1.0	100	100	.04Δ	$h_{FE}:I_C$ - 15A	35	CTP
2N1147				70W	1.0	40	40	.04Δ	$h_{FE}:I_C$ - 15A	35	CTP
2N1147A				70W	1.0	60	60	.04Δ	$h_{FE}:I_C$ - 15A	35	CTP
2N1147B				70W	1.0	80	80	.04Δ	$h_{FE}:I_C$ - 15A	35	CTP
2N1147C				70W	1.0	100	100	.04Δ	$h_{FE}:I_C$ - 15A	35	CTP
GT31	2	PNPA	Ge	125	400	9.0		.80	$h_{fe}:I_e$ - 1ma	20	BTHB
GT32	2	PNPA	Ge	125	400	9.0		1.0	$h_{fe}:I_e$ - 1ma	40	BTHB

NOTATIONS

Under Use

1—Low power a-f equal to or less than 50 mw
2—Medium power a-f > 50 mw and equal to or less than 500 mw
3—Power > 500 mw
4—r-f/i-f
5—Switching & Computer

Under Type No.

A—Alloyed
D—Diffused or Drift
G—Grown
H—Hook Collector
M—Microalloy
O—Other
P—Previously released with new specs
S—Surface Barrier
UNI—Unijunction Transistor
Y—Symmetrical

Under $f_{\alpha b}$

* Maximum Frequency
\# Figure of Merit
Δ $f_{\alpha e}$
Ø minimum

First from **PHILCO**

MADT* TRANSISTORS CONTROLLED IN DESIGN AND MANUFACTURE...

to meet your exact circuit requirements ...NOT SELECTED!

Actual photo of Philco's out-in-front automatic precision etching production equipment.

*Trademark Philco Corporation for Micro Alloy Diffused-base Transistor

New VHF-UHF Transistors available in unlimited quantities – at realistic prices!

Now, Transistor Center, U. S. A., offers a new family of MADT (field flow) transistors in unlimited quantities. Here are precision transistors which greatly expand the design potentials of high-gain, high frequency amplifiers; high speed computers; high-gain, wideband video amplifiers; and other critical high frequency circuitry.

Due to Philco's exclusive electrochemical manufacturing process, MADT's are *controlled* not *selected*. The electrodes are precisely placed in the graded field to produce the exact characteristics you require. MADT's are available immediately in unlimited quantities. Quantities 1 to 99 available "off-the-shelf" from your local franchised Philco Industrial Transistor Distributor.

MADT FAMILY APPLICATIONS DATA

TYPE*	f_{max}	Power Gain	Oscillator Efficiency	Class of Use
2N499	320 mc	10 db at 100 mc		amplifier to 125 mc
2N500			45% at 200 mc	Oscillator to 350 mc
2N501	Ultra high-speed switch typical t_r = 9 mμsec; (18 max.); t_s = 9 mμsec; (12 max.); t_f = 7 mμsec; (10 max.) in circuit with current gain of 10 and voltage turnoff.			
2N502†	800 mc	11 db at 200 mc		amplifier to 250 mc
2N503†	420 mc	12.5 db at 100 mc		amplifier to 175 mc
2N504	50 mc (min.)	46 db at 455		high gain IF amplifier
2N588	250 mc	14 db at 50 mc		Oscillator and amplifier to 80 mc

*Available in voltage ratings up to 35 V and dissipation ratings to 50 mw at 45°C.
†In JETEC TO-9 Case (Widely known as JETEC 30 Case).

Make Philco your prime source of information for high frequency transistor applications.
Write to Lansdale Tube Company, Division of Philco Corporation, Lansdale, Pa., Dept. SP 359

PHILCO CORPORATION
LANSDALE TUBE COMPANY DIVISION
LANSDALE, PENNSYLVANIA

CHARACTERISTICS CHART of NEW TRANSISTORS

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C				Typical Characteristics			MFR. See code at start of charts
				P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha/\beta}$ (mc)	Gain: PARAMETER and (condition)	Gain: VALUE	
GT33	2	PNPA	Ge	125	400	9.0		1.3	h_{fe}:I_e- 1ma	60	BTHB
GT41	2	PNPA	Ge	100	500	9.0		4.0	h_{fe}:I_e- 1ma	30	BTHB
GT42	2	PNPA	Ge	100	500	9.0		6.0	h_{fe}:I_e- 1ma	60	BTHB
GT43	2	PNPA	Ge	100	500	9.0		9.0	h_{fe}:I_e- 1ma	100	BTHB
GT1079	2,5	NPNA	Ge	150	500	20		20Ø	h_{FE}:I_C-400ma	40	GTC
HA7520	3	PNPF	Si	1000	175	35		.80	h_{fe}:I_c- 1ma	9	HUG
HA7521	3	PNPF	Si	1000	175	60		.80	h_{fe}:I_c- 1ma	9	HUG
HA7522	3	PNPF	Si	1000	175	15		1.2	h_{fe}:I_c- 1ma	15	HUG
HA7523	3	PNPF	Si	1000	175	35		1.2	h_{fe}:I_c- 1ma	15	HUG
HA7524	3	PNPF	Si	1000	175	60		1.2	h_{fe}:I_c- 1ma	15	HUG
HA7526	3	PNPF	Si	1000	175	15		1.5	h_{fe}:I_c- 1ma	37	HUG
HA7527	3	PNPF	Si	1000	175	35		1.5	h_{fe}:I_c- 1ma	37	HUG
HA7528	3	PNPF	Si	1000	175	50		1.5	h_{fe}:I_c- 1ma	37	HUG
HA7530	2	PNPF	Si	250	700	35		.80	h_{fe}:I_c- 1ma	9	HUG
HA7531	2	PNPF	Si	250	700	60		.80	h_{fe}:I_c- 1ma	9	HUG
HA7532	2	PNPF	Si	250	700	15		1.2	h_{fe}:I_c- 1ma	15	HUG
HA7533	2	PNPF	Si	250	700	35		1.2	h_{fe}:I_c- 1ma	15	HUG
HA7534	2	PNPF	Si	250	700	60		1.2	h_{fe}:I_c- 1ma	15	HUG
HA7536	2	PNPF	Si	250	700	15		1.5	h_{fe}:I_c- 1ma	37	HUG
HA7537	2	PNPF	Si	250	700	35		1.5	h_{fe}:I_c- 1ma	37	HUG
HA7538	2	PNPF	Si	250	700	50		1.5	h_{fe}:I_c- 1ma	37	HUG
TR123	2	PNPA	Ge	150	400	20	15	8.0	h_{fe}:I_e- 1ma	49	IND
TR269	5	PNPA	Ge	150	400	25	24	12	h_{fe}:I_c- 20ma	40	IND
TR320	2	PNP	Ge	180	360		20	2.5	h_{fe}:I_e- 1ma	48	IND
TR321	2	PNP	Ge	180	360		20	3.0	h_{fe}:I_e- 1ma	48	IND
TR381	2	PNPA	Ge	180	360		25	1.2	h_{fe}:I_c- 20ma	50	IND
TR382	2	PNPA	Ge	180	360	25	25	1.5	h_{fe}:I_c- 20ma	75	IND
TR383	2	PNPA	Ge	180	360	25	25	1.8	h_{fe}:I_c- 20ma	100	IND
TR396	5	PNPA	Ge	150	400	30	20	8.0	h_{fe}:I_e- 1ma	50	IND
TR460	5	PNPA	Ge	150	400	45	10	1.2	h_{fe}:I_e- 1ma	24	IND
TR461	5	PNPA	Ge	150	400	45	10	1.2	h_{fe}:I_e- 1ma	49	IND
TR526	5	PNPA	Ge	150	400	45	25	3.0	h_{fe}:I_e- 1ma	64	IND
TR527	5	PNPA	Ge	150	400	45	25	3.3	h_{fe}:I_e- 1ma	81	IND
TR-C44	4	PNP	Ge	150	400		10	8.0	h_{fe}:I_e- 1ma	80	IND
TR-C45	4	PNP	Ge	150	400		10	4.0	h_{fe}:I_e- 1ma	40	IND
TR-C70	2	PNP	Ge	180	360		16		h_{fe}:I_e- 1ma	30	IND
TR-C71	2	PNP	Ge	180	360		12		h_{fe}:I_e- 1ma	60	IND
TR-C72	2	PNP	Ge	180	360		20		h_{fe}:I_e- 1ma	100	IND
XT515	3	NPND	Si	2800		120			h_{fe}:I_c- 30ma	6	PSI
XT516	3	NPND	Si	2800		120			h_{fe}:I_c- 30ma	6	PSI
XT517	3	NPND	Si	2800		120			h_{fe}:I_c- 30ma	6	PSI
XT518	3	NPND	Si	2800		120			h_{fe}:I_c- 30ma	13	PSI
XT519	3	NPND	Si	2800		120			h_{fe}:I_c- 30ma	13	PSI
XT520	3	NPND	Si	2800		120			h_{fe}:I_c- 30ma	13	PSI

The following manufacturers have announced that they have begun supplying the indicated previously registered transistors.

Industro: 2N311, 2N331, 2N505, 2N564, 2N566, 2N568, 2N570, 2N572, 2N578, 2N579, 2N580, 2N631, 2N632, 2N633, 2N650, 2N651, 2N652, 2N653, 2N654, 2N655

Sylvania: 2N123, 2N139, 2N140, 2N156, 2N168A, 2N169A, 2N217, 2N235B, 2N236B, 2N241A, 2N256, 2N285A, 2N292, 2N321, 2N373, 2N374, 2N399, 2N406, 2N408, 2N409, 2N410, 2N411, 2N412, 2N419, 2N420, 2N439, 2N525, 2N544, 2N585, 2N591

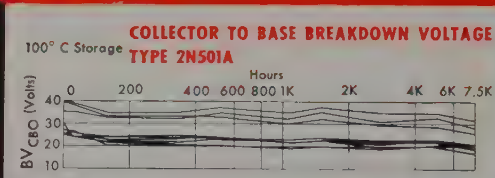
Transitron: 2N339, 2N340, 2N341, 2N342, 2N343, 2N656, 2N657

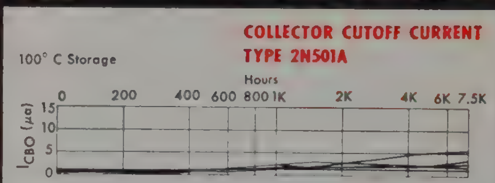
PHILCO

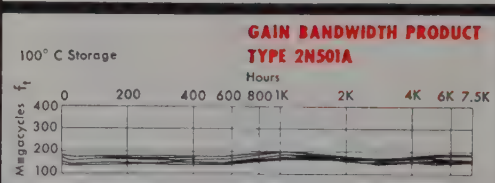
MADT* Transistors

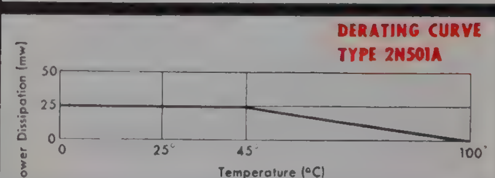
RATED AT 100°C

deliver outstanding switching performance









High frequency, high gain Transistor offers excellent stability and operating efficiency in extensive environmental testing

Modern advances in electronics necessitate highest possible temperature performance from germanium transistors. Philco 2N501A transistors are designed for switching speeds of less than 18 millimicroseconds rise time, 12 mμsec. storage time and 10 mμsec. fall time . . . AND STORAGE TEMPERATURES UP TO 100° C. (see curve at right for derating factor). In extensive life tests (see graphs at right) these transistors exhibit excellent parameter stability at 7500 hours.

Philco's long and successful experience with electrochemical techniques and automatic transistor production, assures precise control of micro alloy diffused-base transistor performance. Philco know-how pays off for you . . . in outstanding uniformity and reliability of all transistors produced at Transistor Center, U.S.A.

Make Philco your prime source for all Transistor information.

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**Trademark Philco Corporation for Micro Alloy Diffused-base Transistor.*

PHILCO CORPORATION

LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNSYLVANIA

TRANSISTOR CENTER U.S.A.

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New Literature

(from page 69)

General Transistor Corporation announces the availability of a brochure covering specifications on their line improved high frequency germanium alloyed junction transistors types 2N444 through 2N447A and 2N519A through 2N523A.

Circle 63 on Reader Service Card

The CBS-Hytron Technician's Handbook for 1959, recently announced, packed with more than 550 pages of up-to-the-minute information on electron tubes and semiconductors. It features over 1,000 receiving tubes and 330 picture tubes as well as data on transistors, crystal diodes, and special-purpose tubes.

Circle 64 on Reader Service Card

A new bulletin gives full specifications on new Vickers 1290 Series Super Power gapless core magnetic amplifiers. The series consists of eighteen standard sizes with power outputs of 500 VA to over 32 KVA. It includes tables of electrical characteristics, curves, basic circuit diagrams and outline and mounting dimensions for both amplifier reactor units and rectifiers.

Circle 65 on Reader Service Card

A new four-page technical folder describing the application of high-purity tantalum to the electronic, nuclear, chemical and missile industries is now available from National Research Corporation. The brochure describes the various forms in which the new product is available, including powder for electronic uses, vacuum melting stock, arc cast ingot for conversion, and tubing, sheet, wire, foil and other mill products. Detailed tables give the exact chemical analysis (impurities in parts per million) and mechanical and physical properties of the new products.

Circle 66 on Reader Service Card

A new six-page folder, describing the qualities of their ceramic disc capacitors, has been published by the Electro Motive Mfg. Co., Inc. It includes complete specifications data, charts and graphs on the performance capabilities of their line of temperature stable, semi-stable, general purpose, and temperature compensating units. They are available in 500 *wvdc* or 1,000 *wvdc*, are wax-impregnated with low-loss phenolic coating and have a flat design that assures reduced self-inductance.

Circle 67 on Reader Service Card

A brochure on their complete line of button cell miniature batteries, is announced by Gulton Industries, Inc. The four-page, colored and illustrated brochure, highlights the features, design potentials and specifications of the VO-Series, nickel cadmium, button cell battery line which includes types from 100 MAH to 1750 MAH capacities in more than 50 distinct sizes and voltages. The cells are rechargeable and hermetically sealed.

Circle 68 on Reader Service Card

A 12-page, 2-color catalog by Mesa Plastics Co. describes the "DIALL" line of Diallyl Phthalate plastic molding materials. Advantages of the plastics are listed, showing their insulating qualities and dimensional stability under severe environmental conditions. Complete property and molding data charts are supplied for dacron-filled, asbestos-filled, glass-filled and orlon-filled types.

Circle 73 on Reader Service Card

PERSONNEL NOTES

The appointment of J. R. Juncker as Military Relations Engineer for the Semiconductor-Components division was announced by Texas Instruments Incorporated. With headquarters at 1141 East Jersey Street, Elizabeth, New Jersey, Mr. Juncker will service the engineering requirements of all Northeastern government procurement agencies for the TI Semiconductor-Components division. His area of operation includes Pennsylvania, New Jersey, New York, Rhode Island, and Massachusetts.

Two new regional sales offices have been opened and the sales staff expanded for the semiconductor product line of the Red Bank division of Bendix Aviation Corporation. Offices were opened in Chicago to serve the Midwest area, and in Tewksbury, Mass. for the New England and upper New York state areas, according to Dr. Robert R. Meijer, marketing manager for semiconductors. Charles W Jackson has been appointed district sales manager for the Chicago office, and Donald I. Snell named to direct sales from the New England office.

The appointment of Dr. Sherrerd B. Welles as senior engineering specialist for Sylvania Electronic Systems, a major division of Sylvania Electric Products Inc., has been announced by Dr. Edwin G. Schneider, chief engineer of Sylvania Electronic Systems. Dr. Welles will be responsible for improving and maintaining the interchange of technical information, both within the division and between Sylvania Electronic Systems and other divisions of the corporation. He will make his office at the division headquarters, 100 First Avenue, Waltham, Mass.

General Electric's Semiconductor Products Department has established a Rectifier Product Section with C. Graydon Lloyd, of Skaneateles, N.Y., as general manager. In making the announcement, Department general manager, H. B. Fancher, said the reorganization was necessitated by the department's rapidly expanding activities in the semiconductor components field. Mr. Lloyd is a senior member of the Institute of Radio Engineers, and the American Institute of Electrical Engineers.

Dr. W. Crawford Dunlap has been named director of semconductor research for the Research Division of Raytheon Manufacturing Company. Dr. Dunlap is a Fellow of the American Physical Society, a senior member of the Institute of Radio Engineers, chairman of the basic science committee of the American Institute of Electrical Engineers, and member of the Union Radio Scientifique International, international governing body of radio and electronics. He has authored numerous articles for the top scientific journals, and presented technical papers to many national societies.

The appointment of Elmer J. Perry to the newly created post of manufacturing manager of the Semiconductor Division of Sylvania Electric Products Inc. has been announced by Dr. William J. Pietenpol, division vice president and general manager. Mr. Perry, who has been man-

ager of Sylvania's semiconductor plant at Hillsboro, N. H., will be located at division headquarters in Woburn, Mass. In 1954, he was named manufacturing superintendent, transistors, for Sylvania's Semiconductor Division at Woburn, Mass. After that, he was appointed manager of the Hillsboro plant when it was placed in operation in 1956.

Hughes Aircraft Company has established offices in the Far East and Europe. Rollin M. Russell, vice-president and manager of the company's International Division, announced recently. Far East operations will be centered in Tokyo with Edwin P. Ramsey, at present a divisional staff assistant, in charge. George E. Todd, manager of corporate customer relations, will head the European operation with headquarters in Paris.

Dr. J. Earl Thomas, widely-known university physicist, has joined the engineering staff of the Semiconductor Division of Sylvania Electric Products Inc., it was announced by William J. Pietenpol, divisional Vice President and general manager. Head of the Physics Department at Wayne State University, Detroit, and a recognized authority on solid state physics, Dr. Thomas will continue his university affiliation until next June when he will assume full responsibility for the research and engineering activities of Sylvania's Semiconductor Division, according to Dr. Pietenpol.

Dr. Mervin J. Kelly, chairman of the board of Bell Telephone Laboratories, has been elected a director of Tung-Sol Electric Inc., it was announced recently. Dr. Kelly will receive the 1958 James Forrestal Memorial Award of the National Security Industrial Association for advancing American defense and the 1959 John Fritz Medal for "his achievements in electronics, leadership of a great industrial research laboratory and contributions to the defense of the country through science and technology."

Appointment of Frank J. Newman as marketing manager for the Shockley Transistor Corporation, a subsidiary of Beckman Instruments, Inc., is announced by Maurice C. Hanafin, vice president and general manager of the Shockley organization. Mr. Newman holds degrees in electrical engineering and economics from Brown University and a master's degree in business administration from Columbia University. He is a member of the Instrument Society of America.

Leon Robbin has been elected to the Board of Directors of P. R. Mallory & Co. Inc., Indianapolis, manufacturer of electronic, electrical and specialized metallurgical components. Mr. Robbin has been associated with the company for twenty-five years in various capacities including legal, patent, engineering and battery activities. He has been a Vice President for eighteen years.

John R. Harkness has been appointed to the new post of electronics manager at Bendix-Pacific division of Bendix Aviation Corporation, it was announced by R. C. Fuller, general manager. Mr. Harkness' experience in electronics, spans 20 years. He is an electrical engineering graduate of the University of Southern California, and a member of Eta Kappa Nu, honorary electrical engineering fraternity.

Dr. Vance Foster has been promoted to Applications Engineering Manager of Potter & Brumfield, Inc., according to Zeke R. Smith, vice-president and Director of Engineering. Mr. Foster, an employee of the relay manufacturing firm for 15 years, has headed the test, adjust and inspection department and was Applications Laboratory Supervisor prior to this promotion.

Appointment of Robert W. Teichner to the technical staff of Shockley Transistor Corporation has been announced by M. C. Hanafin, vice president and general manager of this subsidiary of Beckman Instruments, Inc. His initial responsibilities will include the development of precision techniques for semiconductor devices which are closely related to printed circuit techniques found in other branches of electronics. Mr. Teichner has a degree in chemical engineering from the Polytechnic Institute of Brooklyn and a master's degree in chemistry from Harvard University. He is a member of the American Chemical Society and the Technical Association of the Graphic Arts.

Professor William M. Surber of the Electrical Engineering Department of Princeton University, has been appointed a consultant of General Devices, Inc., Princeton, New Jersey, as announced by its President, Mr. John Brinster. Professor Surber received a B.S. degree in physics from the University of Richmond and both master's and doctor's degrees in electrical engineering from Princeton University. He is well known for his work in the fields of microwave measurements, nonlinear systems and feedback control systems.

Raymond Stuart-Williams has been elected a vice president of Telemeter Magnetics, Inc. of Los Angeles. Mr. Stuart-Williams will continue to direct the engineering department, it was stated by Erwin Tomash, president of the company. Mr. Stuart-Williams, a graduate of Glasgow University, has been intimately associated with the computer and data processing field for more than sixteen years. He holds numerous patents on computers and core storage devices.

The Houston Instrument Corporation has been organized for the development, manufacture and sale of laboratory instruments and specialized industrial instruments for the petroleum and chemical industries. It will have offices at 1717 Clay Ave., Houston 3, Texas. The new organization will be headed by E. V. Hardway, Jr. of Houston. The Laboratory Instruments Division will be headed by Mr. Jack Yeiser.

The appointment of two East Coast sales liaison engineers for Tamar Electronics was announced recently by Vern Landis Jr., vice-president and general manager. Representing the Wright-Patterson Field area is William Klein; Charles Meuche will cover the general east coast including New York and Washington. Both are graduate electronic engineers, with a combined background of 24 years experience in communication, radar, and electronic countermeasures.

Westbury Electronics, Inc. announces the formation of its Magnetic Products Division, operations having commenced December 1, 1958. The new division is under the direction of R. Mgrdechian who has been appointed General Manager of the Magnetic Products Division. Mr. Mgrdechian was formerly Chief Engineer of Keystone Products Company and before that Chief Engineer of Carol Electronics.

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